Different Process Parameters and Technique used for Heat Transfer Enhancement in Solar Heat Exchanger: A Review

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***Abstract*: The solar energy is the most abundant form of energy available in the universe and therefore it is most alternative energy source as compared to the other conventional energy sources. Now a day due to increase in requirement of energy and rising cost of fossil type fuels (i.e., gas or oil) solar energy is considered a most attractive source foam of renewable energy that can be used for heat generation that is heating purpose at both homes and industry. Solar heat exchanger is mainly used for heating air and water or used for trapping energy from solar radiation. The solar heat exchanger is designed to meet the requirement of energy demands as per the requirement. The size of the heat exchanger depends on availability of solar radiation, heat transfer rate, temperature requirement according to used, geographical condition and arrangement of different solar system. In order to design the solar heat exchanger it is important to know different parameters on which the performance of solar heat exchanger depends. Many of the researcher used nano fluids and also work on the creation of turbulence inside the heat exchanger to increase the performance of heat exchanger. Therefore here in this paper it reviews the different types of solar heat exchanger used, different methods used to increase the performance of solar heat exchanger. The also reviewed the process parameters on which the performance of heat exchanger depends.**

***Keywords*- heat transfer, solar heat exchanger, Nano fluid, solar energy, flow behaviour**

1. Introduction

Today, conventional fuel has been primarily used as a main source for heat and power generation. It is convenient to use coal, oil and natural gas for meeting human's energy needs, but there is a limited amount of conventional fuel is available so supply of these fuels has become the main constraint for people to use it as continuous sources of energy. As energy plays a crucial role in the daily needs of humans, there are different alternative source of energy that can used as a fuel instead of fossil fuels, and one of the most desirable renewable source of energy is solar energy. It was recounted that the present conventional fuel consumption was 105 times faster than the amount of fuel generated by nature. Predictably, at this huge 75 rate of consumption, the world's fossil fuel reserves will diminish by 2050.

Considering other alternatives, solar energy stands a promising future of renewable energy. Solar energy is free and provides an infinite and eco-friendly reservoir of energy. The easiest way to utilize solar energy is by converting it into thermal energy using solar collectors. Air heating is one of the major solar thermal applications, used for space heating and process heating like laundry, desalination, crop drying and other drying processes. Utilizing of conventional electrical energy for this process will increase the process cost as well as pollute the environment. Using solar energy for air heating will reduce the operational cost of the system, environmental free and reduce the consumption of conventional energy.

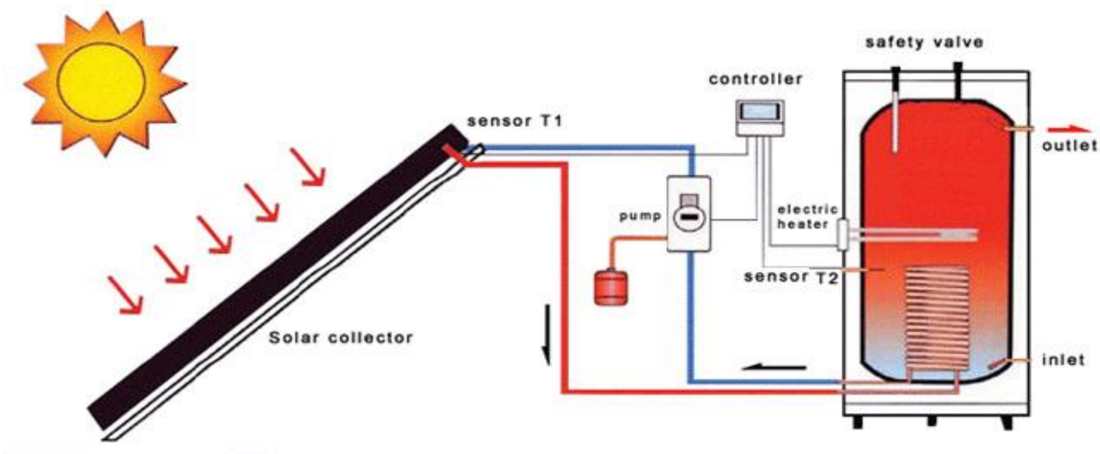

Fig.1 solar heat exchanger system

To increases the performance of solar heating system it is necessary to increases the efficiency of heat transfer mechanism used in solar heat exchanger. To increase the efficiency of heat exchanger different methods were developed to trap maximum amount of solar energy. Many researchers proposed different method and technique to trap solar energy and also optimized the different process parameters of solar heat exchanger. Here in this work a brief review of different solar heat exchanger is done to identify the parameters on which the performance of heat exchanger depends.

2. Existing Research work

Many of the researchers work in the field of solar heat exchanger and optimized the different parameters. Researcher mainly used solar energy to heat air and water. To increase heat transfer rate different kind of working fluid were used. Many people uses the nano particles of metal like titanium oxide, copper oxide, aluminium oxide and many others to increase heat transfer rate, some of the work is mention hear in the below section

1. **Ehsan Ebrahimnia-Bajestan et.al (2016)** In the present study here, advanced systems of developing heat transfer as the heat exchangers characteristics in solar systems is applying nanofluids as the heat transfer medium. The analysis focuses on laminar heat transfer which is convective in nature of water based TiO2 nanofluid moving through a uniformly heated tube is being examined through practical and mathematical modelling. Therefore, some changes are executed to the collective two stage model in order to attain more exact calculations of the heat transfer features of nanofluids. This improved model considered the influence of particle concentration, particle radius, as well as particle and base fluid material on the rate of heat transfer at different Reynolds numbers.

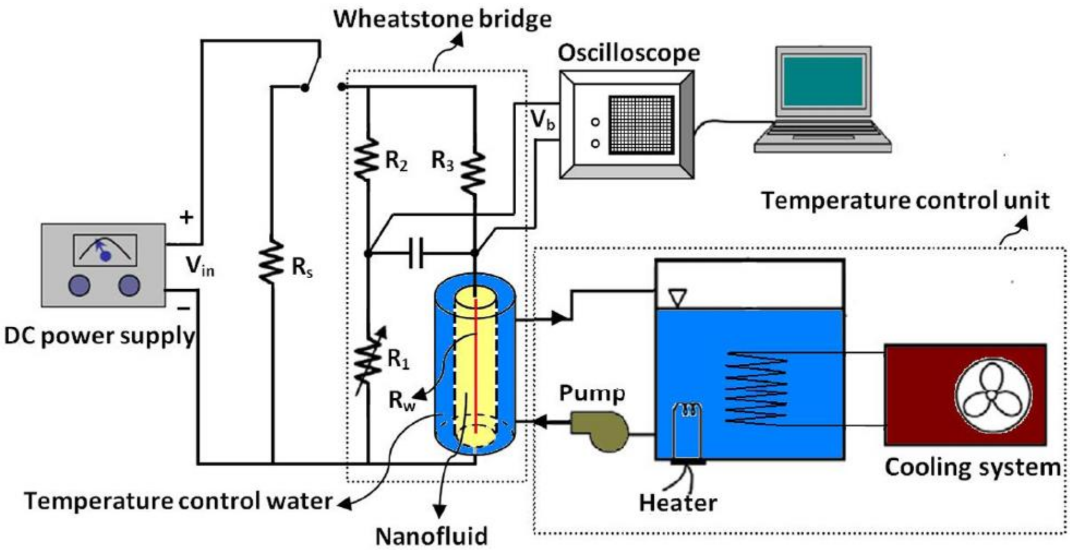

Fig.2 Schematic diagram of transient hot water technique for viscosity measurement at different temperature [1]

The outcomes specified that the common single phase method, though with measured, temperature dependent, thermo-physical properties; take too lightly the convective heat transfer features of nanofluids. Moreover, the common two stage Eulerian model failed to forecast the rates of heat transfer precisely.

2. Alibakhsh Kasaeian et.al (2015) In this research work we analyse the negative influence of human events on the environment receives incredible consideration, particularly on the increased global temperature. To tackle the climate change, clean as well as viable energy sources need to be promptly established. Studies in this field offers unique advantages over conventional fluids which indicate the exploiting nanofluid in solar system. At the side of extensive range of energy transformation, the efforts made on the energy storage system are being studied. Based on the literatures, the enhanced thermal conductivity of nano fluid is the supremely significant element or for improving the efficiency in solar systems whereas a greater solid volume fraction does not every time improve the effectiveness. Utilizing nanofluid in solar systems includes many environmental and economic beneficial features such as reducing of CO2 emission through improving the efficiency, also less emission in manufacturing process of nanofluid-based collectors.

3. P. Chandrasekaran et.al (2014) The present analysis aims to examine the solidification features of water based nanofluid phase change material. By separating copper oxide nanoparticles and a nucleating agent in the base phase change material the nanofluid phase change material has been arranged. In the phase change material and by allowing the evaporator to activate at a higher temperature in a chiller where the presence of nucleating agent abolished the splitting problem of subcooling. The accelerated charging been recognized for the first quarter of solidification time, through which half of the mass solidified in both phase change material and nanofluid phase change material.

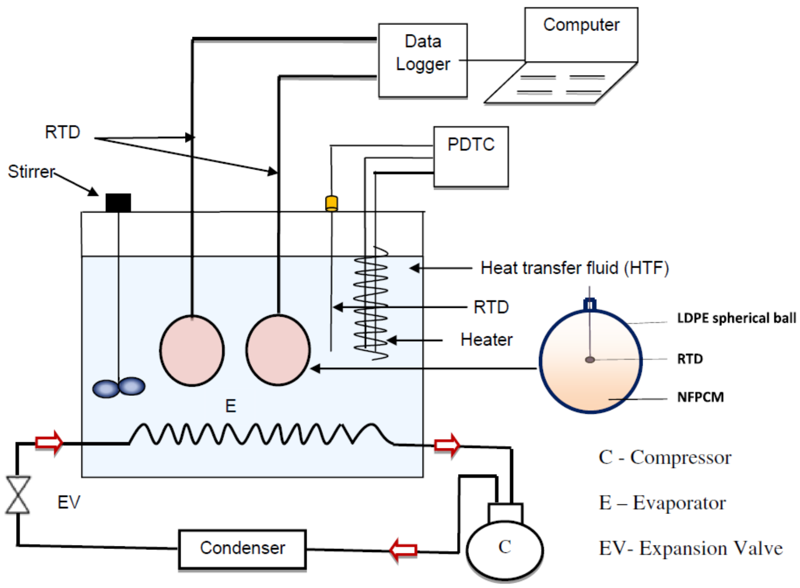

Fig.3 Schematic diagram of the experimental setup [3]

4. Ali Najah Al-Shamani et.al (2014) In the present paper the utilization of nanofluids for cooling is a fascinating substantial care in numerous applications of the firm. Likened with conservative fluids, nanofluids advance the rate of heat transfer, as well as the visual things, thermal properties, effectiveness, and transmission as well as elimination coefficients of solar systems. The influence of different nanofluids on the cooling rate and hence the efficiency of solar systems may be practically examined.

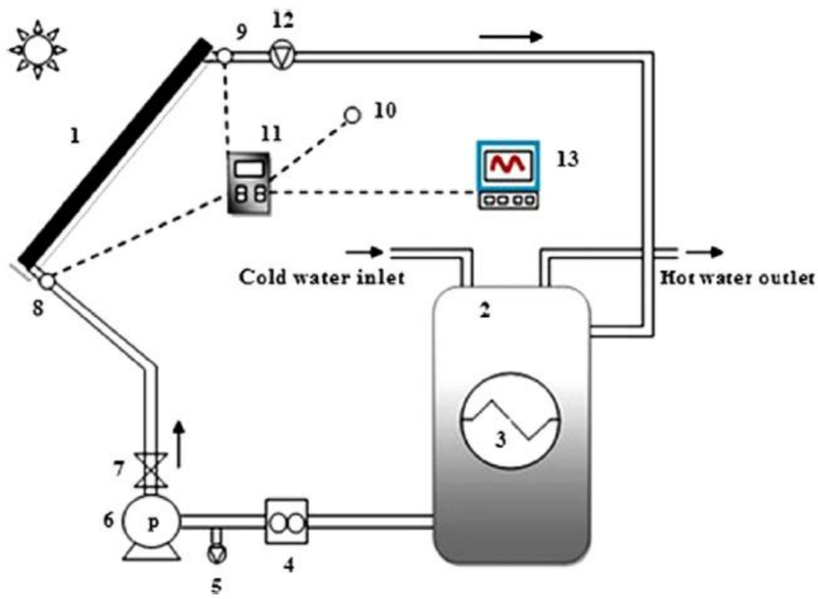

Fig.4 the schematic of the experiment [4]

The next part of this topic is a major concern which gives a summary of the research, performance, as well as progress in photovoltaic or thermal collector systems. Explanations are made on water photovoltaic or thermal collector types, logical and mathematical models, imitation like practical works. Nanotechnology permits the manufacture of nano-scaled particles.

5. Z. Said et.al (2014) in this paper the review academically focuses on entropy generation, improvement of heat transfer competences as well as drop in pressure for a flat-plate solar collector functioned with single wall carbon nanotubes based nano fluids like captivating medium. It is perceived that the single wall carbon nanotubes the nanofluid decreases the entropy generation by 4.35 percent and improve the coefficient of heat transfer by 15.34 percent tentatively likened to water as an absorbing fluid. Pumping power forfeiting of nanofluid worked as solar collector is obtained to be 1.21 percent more than the water as a working fluid. Practically insignificant influence in the pumping power as well as drop in pressure is detected for the analysed volume fraction of single wall carbon nanotubes nanoparticles.

6. Thaklaew Yiamsawas et.al (2013) In this analytical work the practical inquiries are achieved to find the viscosity of TiO_2 and Al_2O_3 nanoparticles suspended in a blend of ethylene glycol/water. The tests are directed at numerous fractions of volume between 0% as well as 5% and a temperature varies from 15–60°C. Some assessments are ready between the practical outcomes and the theoretical models as well as connections existing for viscosity in the literature. Finally, a helpful association is offered to compute the viscosity of nanofluids in which the viscosity of nanofluid as a function of temperature, volume fraction of nanoparticles, and the viscosity of base fluid.

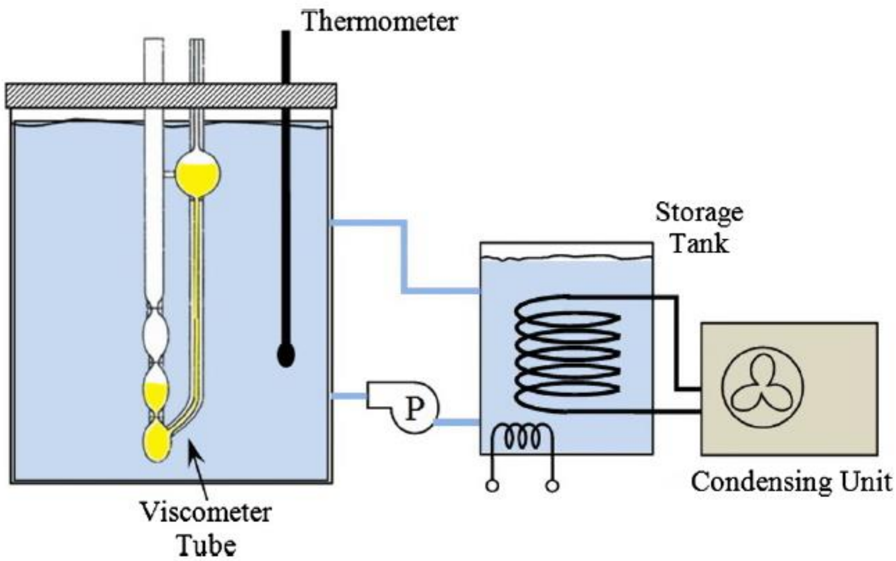

Fig.5 Schematic of the experimental set up used.[6]

7. M. Faizal et.al (2013) In this research paper a solar thermal system the increment in the heat transfer area can rise the exit temperature of the system. Nevertheless, this method leads to a superior as well as huge collector. It will then proliferate the expense and energy needed to fabricate the solar collector. The efficiency, size reduction, cost and embodied energy savings are considered for various nanofluids by utilizing mathematical means as well as data from literatures. It may be determined that, Greater density and lesser specific heat of nanoparticles getting to the higher thermal efficiency and CuO nanofluid have the highest value linked to additional three nanofluids.

8. F.S. Javadi et.al (2013) The present research work is the widespread outlook of the exploration advancement rise in the presentation of solar collector by utilizing nanofluids. The upsurge in the value of fossil fuels as well as rapid depletion of conventional energy sources are amongst the main energy concerns. Many researchers estimated these special properties of nanofluids, by means of numerous of approaches and practices. Measured and mathematical techniques are proficient and practical methods coming to authenticate the outcomes. By means of utilizing nanofluid in place of conventional fluid recovers heat transfer as well as optical and thermal assets, effectiveness, transmittance and extinction coefficient of solar collector. Likewise, the power should be made to achieve two phase exploration of nanofluid and analyse the properties of nanofluid with more than one type of nanoparticle.

9. OmidMahian et.al (2013) In the present research paper we investigate by applying nanofluids as an innovative kind of liquid mixture with a small attention of nano sized solid particles in suspensive order to a relatively new region, which is less than two eras old. The objective of this analysis of the nanofluid bids in solar thermal production systems. Consequently, the main part of this study assigned to the influence of nanofluids on the performance of solar collectors as well as solar water heaters from the effectiveness, economic as well as environmental deliberations in a view facts. In addition, around the described mechanism on the submissions of nanofluids in thermal energy storage, solar cells, as well as solar stills are revised.

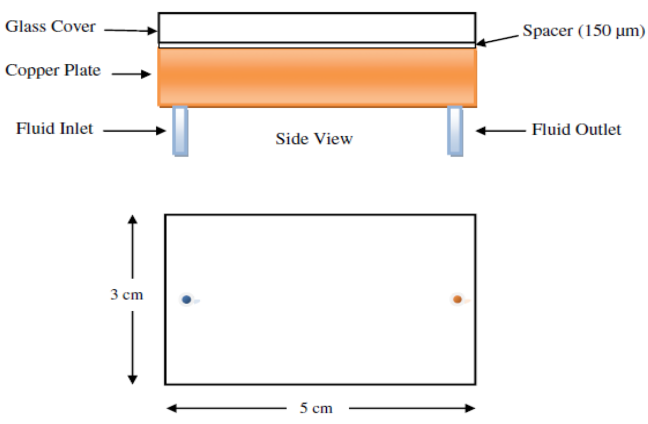

Fig.6 Experimental schematic of the micro-solar thermal collector used during the analysis[9]

10. M. Chandrasekar et.al (2011) In this analysis here the heat transfer properties of water-based nano crystalline alumina nanofluids flowing through a uniformly heated tube under a fully developed laminar and turbulent flow regime is investigated experimentally in the present work to explore the heat transfer mechanism in nanofluids. Experimental investigations on convective heat transfer characteristics of Al2O3/water nanofluid were carried out in fully developed laminar and turbulent regions of pipe flow with constant heat flux. The following observations were made from the investigation. The heat transfer coefficient is increased by a maximum of 16%, 23%, and 33% with nanofluids having volume concentrations of 0.2%, 0.13%, and 0.3%, respectively, compared to distilled water in the entry length under laminar flow.

11. **R. Mokhtari Moghari et.al (2011)** In the present research there is an enhancement of heat transfer of a mixed convection laminar Al2O3–water nanofluid flow in an annulus with constant heat flux boundary condition has been studied employing two phase mixture model and effective expressions of nanofluid properties. Three dimensional Navier–Stokes, energy and volume fraction equations have been discretized using the finite volume method while the SIMPELC procedure has been introduced to couple the velocity–pressure. The calculated results show that at a given Re and Gr, increasing nanoparticles volume fraction increases the Nusselt number at the inner and outer walls while it does not have any significant effect on the friction factor.

12. **Mohammad Kalteh et.al (2011)** In this research here we analyse the laminar forced convection heat transfer of a copper–water nanofluid inside an isothermally heated micro-channel is studied numerically. An Eulerian two-fluid model is considered to simulate the nanofluid flow inside the micro-channel and the governing mass, momentum and energy equations for both phases are solved using the finite volume method. It is observed that the relative velocity and temperature for base liquid and nanoparticle phases are very small and negligible. Thus, the liquid and the nanoparticles have almost the same velocity and temperature. Also, the nanoparticle volume concentration distribution is uniform in the computational domain. Therefore we conclude that considering the nanofluid as a homogeneous solution is reasonable.

13. S. ZeinaliHeris et.al (2009) In this analysis the fluids in which nanometer-sized solid particles are suspended are called nanofluids. These fluids can be employed to increase the heat transfer rate in various applications. In this study, the convective heat transfer for Cu/water nanofluid through a circular tube was experimentally investigated. The results show that the heat transfer coefficient is enhanced by increasing the nanoparticle concentrations as well as the Peclet number. The Cu/water nanofluid forced convection heat transfer performance in a circular tube was experimentally investigated. The flow was laminar, and the thermal boundary condition was a constant wall temperature

14. Doohyun Kim et.al (2009) In the present analysis to inspect the effect of nanofluids on convective heat transfer, an experimental study has been performed through a circular straight tube with a constant heat flux condition in the laminar and turbulent flow regime. Stable nanofluids, which were water-based suspensions of alumina and amorphous carbonic nanoparticles, were prepared by two- and one-step methods. For the amorphous carbonic nanofluids at 3.5 vol%, the thermal conductivity was similar to that of pure water at 21°C, and the enhancement of convective heat transfer coefficient increased only to 9% in laminar flow, while no convection increment was shown in turbulent flow.

15. Liang Liao et.al (2009) In this study here compensation in the consideration to the conclusion of fluid temperatures on the forced convective flow drag as well as heat transfer properties of multi wall carbon nanotube water suspensions starved of any surfactants. Although the heat transfer of multi wall carbon nanotube suspensions with great mass absorption or high fluid temperature is expressively improved. The suspension offers parallel flow features like pure water. The coefficient of heat transfer of the suspension rises with the increase in the multi wall carbon nanotube attention. It also upsurges abruptly with the proliferation of the fluid temperature.

Table. Shows the existing Research work for solar heat exchanger

S.NO.	Authors Name	Input Parameter	Types of Nanofluids Used	Output Parameter	Types of Analysis
1.	EhsanEbrahimnia-Bajestan et.al (2016)	Length, Temperature, Reynolds no.	Nanofluids heat transfer in solar heat exchanger	Nusselt no.,Viscosity, thermal conductivity, avg. heat transfer coefficient	Experimental and Numerical Analysis both
2.	AlibakhshKasaeian et.al (2015)	Volume fraction, Particle diameter, heat transfer rate	Nanofluids in solar energy system	Collector Efficiency, heat transfer coefficient	Experimental Analysis
3.	P. Chandrasekaran et.al (2014)	Size ,Time	Nanofluids phase change materials	Intensity, Temperature	Experimental Analysis
4.	Ali Najah Al-Shamani et.al (2014)	Reynolds no., Particles diameter	Nanofluid in cooling solar collector	Average heat transfer coefficient,	Experimental Analysis

				Collector Efficiency	
5.	Z. Said et.al (2014)	Volume flow rate, Volume fraction	Nanofluid based on flat plate solar collector	Entropy generation, exergy, heat transfer coefficient	Numerical Analysis
6.	ThaklaewYiamsawas et.al (2013)	temperature	Nano Particles using titanium oxide and alumina viscosity	Dynamic viscosity	Experimental Analysis
7.	M. Faizal et.al (2013)	Volume flow rate, Volume fraction	Metal oxide Nanofluid	Density, Efficiency	Numerical Analysis
8.	F.S. Javadi et.al (2013)	Volume flow rate, Time	Nanofluid solar collector	Efficiency, Temperature	Numerical Analysis
9.	OmidMahian et.al (2013)	Volume fraction, Particle size	Nanofluid in solar energy	Collector Efficiency	Experimental Analysis
10.	M. Chandrasekar et.al (2011)	Axial distance, Reynolds no.	Nanofluid with Nanocrystalline	Nusselt no., heat transfer coefficient	Experimental Analysis
11.	R. MokhtariMoghari et.al (2011)	Heat flux	Nanofluid with water and alumina	Nusselt no.	Numerical Analysis
12.	Mohammad Kalteh et.al (2011)	Reynolds no.	Nanofluid with micro-channel	Nusselt no.	Numerical Analysis
13.	S. ZeinaliHeris et.al (2009)	Shear rate, Peclet no.	Nanofluid with circular tube	Viscosity, Nusselt no.	Experimental Analysis
14.	Doohyun Kim et.al (2009)	Temperature, Axial position	Nanofluid with laminar and turbulent condition	Thermal conductivity, Viscosity, Nusselt no.	Experimental Analysis
15.	Liang Liao et.al (2009)	Temperature, Flow drag	Nano tube of carbon with suspension	Thermal conductivity, Viscosity, Reynolds no.	Experimental Analysis

Conclusion

The solar energy is the renewable source of energy which is available in abundant quantity; it is mainly used for heating air and water. To increase the heat transfer of solar heat exchanger different parameters where optimized. To increases the heat transfer inside the solar heat exchanger nano fluids were used, due to which the heat carrying capacity of working fluid increases. The heat transfer inside the solar heat exchanger is also increase with the increases in turbulence inside the solar heat exchanger. To increase the turbulence inside the heat exchanger different types of turulators were used.

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