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Research Article

Experimental Investigation on Thermal Efficiency of a Solar Collector with Helical Coil Tube using MWCNT/WATER

Dr.K. Palanisamy[a], P. Gokulananth[b], T. Monish[c], M. Mukesh[d]

[a]Professor, Mechanical Engineering, M. Kumarasamy College of Engineering, Tamilnadu, India.
[b]UG Student, Mechanical Engineering, M. Kumarasamy College of Engineering, Tamilnadu, India.
[c]UG Student, Mechanical Engineering, M. Kumarasamy College of Engineering, Tamilnadu, India.
[d]UG Student, Mechanical Engineering, M. Kumarasamy College of Engineering, Tamilnadu, India.

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Abstract: The thermodynamic energy conversion efficiency collector was experimentally studied in this investigation with helical coil tube using MWCNT (Multi Walled Carbon Nano Tube). The collector is made up of a curved glass tube with a helical coil as the solar power receiver. Also, these efficiencies with MWCNT nano fluid far from isoelectric points higher than other nano fluid. The MWCNT/water nano fluids were prepared in two steps with the addition of surfactant at particle volume concentrations of 0.1, 0.3, and 0.5 percent. The prepared MWCNT/water nano fluids are found to be safe even after 4 weeks of preparation, with no considerable deposit of nano ducts on the tube interior layer. There no immediate risk in dealing with MWCNT and it is being studied and inspected MWCNT exhibits no extreme threat, and it is being studied and thoroughly checked. Therefore, MWCNT / water nano fluids transfer heat transfer fluids with a significant pressure drop to conventional fluids in a helical, enhance heat transfer, use a coiled tube heat exchanger. Adequate performance of elevated materials Chemical, petroleum, temperature is a potential issue in many systems process and power generation industries. Decomposition of materials is caused by the interaction between the structural material and the exposure environment.

Keywords: Solar Collector, Efficiency, Nano tube & Coil

1. Introduction

Heat exchangers are widely used in process transfer companies Steam power plants, nuclear reactors, Refrigeration and refrigeration structures, Material preparation, Food businesses and Medical Gear. The increase in the heat transfer coefficient improves the display of thermal. Reduces size of the exchanger and heat exchanger. Solar water warming Structures are one of the constant power improvements in private structures, the use of non-renewable energy sources can be reduced like related environmental issues. Since regular solar fluids are like water, Ethylene glycol and propylene glycol are powerless protectors, add nano Particles have been proposed for a fluid that acts as a retention medium. Because the low thermal conductivity of ordinary liquids creates a real limit improving the exhibition of warm-up activities, like solar authorities Control will be greater with the use of nano fluids. On the helical Coil heat exchangers, the coil width remains the same, thus generating power in seconds the constant temperature will remain intact which will have an impact on the moving coefficient. Helical coil. The width of the calculation coil changes constantly and deeply More area. This constant change of width modifies the movement of the adjacent warmth Coefficient from depth to outer area. MWCNTs as nano fluid Considering the nearby sun, the sun-based range is exceptionally well maintained 100% solar powered energy integration, low focus and even small scale Classification blocks. Nano fluids have a lower thermal range than normal Fluids, the use of nano fluids in solar-powered collectors in this way the basic collection of solar powered gadgets triggers expansions. The outlet temperature of the power. Impact of adding surfactant with MWCNT expands productivity by up to 15%.

2. Literature Survey

Roonak Daghigh et all (2018), the experiment investigation, MWCNT nanoparticles were considered for all condenser configurations and outstripped other working fluids due to its higher thermal expansion coefficient conductivity. K. Goudarzi et al (2015), the experimental investigation on the more difference of pH in nano fluid MWCNT nanostructures outperformed other nanofluids in all diffuser combinations due to their higher heat transfer coefficient capacitance. Wei peng et al (2020), the experimental study on using sequenced reflections of Rays of the sun in the absorber tube helps in decreasing amount of nanoparticle, but as a result, agglomeration and semi heat exchange decrease, while concentration rises.

Yousefi et al (2012), applied Al2O3–H2O, nanofluid was used as the heat transfer fluid, and its influence was particularly in comparison to that of water. The efficiency of the solar collector with 0.2 wt. percent natural convection increased by approximately 28.3 percent when compared to water, according to their experimental results. Bellos et al. (2020) studied the performance of a PTC using a combination of thermal and electrical techniques. It is realised in its final results.

Kalogirou et al (2004), results of the experimental investigation revealed that the nanofluids MQL lubricating oils, both paraffin and animal fats, reduced significantly hydraulic fracturing torques and nearly doubled the number of drilled holes. They also found that glycerine oil-based nanofluid MQL was more effective than the veggie broth version. Santhosh Bopehe and others (2020), This occurs during the conversion of photovoltaic energy. Huseyin Kaya et al. (2020), Nanofluids with concrete block nanomaterial exceed platelets and blade-shaped ones under the same system parameters.

Yijie Tong et al (2020), when compared to water, the use of water nanofluid in a solar flat plate collector results in efficiency and reduced responsivity to various process parameters. MWCNT nanoparticles had a higher thermal conductivity than the other nanoparticles. Dan Zheng (2020), an experimental study on the heat transfer characteristics and heat transfer variations nanomaterials.

Rashidi et al (2017), in this review, the implementations of polymeric media, as well as their benefits and challenges on various types of solar energy systems, are summarized. Furthermore, the buildings of each model, as well as about their implementations, are briefly described. This paper discusses solar energy systems that include both energy transition and power systems. E. Natarajan et al. (2009) studied the performance balance control of base fluids using carbon nanotubes (CNT) and recommended that if this water is used as a thermal transfer medium, the efficiency of a traditional heat exchanger rises. Taylor et al. (2011) demonstrated the effect of graphite nanoparticle-based water nanofluid on the performance of high flux solar panels decided to show that the use of nanoparticles improves efficiency by up to 10%.

3. Experimental Description

3.1. Cylindrical Glass

The collector comprises of tube shaped glass which goes about as a recipient of solar energy. The elements of tube shaped glass is referenced previously. The glass which has high ingestion limit consequently engrossing the solar radiation and communicate to the copper tube. It likewise has most extreme transmissivity and its thickness is 0.25cm.

3.2. Copper Tube

Copper cylinder can be utilized as helical sort to improve the most extreme warmth move of the liquid. The pitch of the cylinder is 2.5cm and the quantity of turns are 24. The inward, external width of the cylinder is referenced in the and the cylinder which goes about as an exchange mode for the coolants to move the warmth source. The sensor, for example, thermocouples and the pressing factor measure additionally fitted in the cylinder to detect the channel and outlet temperatures and pressing factors individually. Typically, the copper has high warmth move limit than the other which is alluded in HMT information book Page (2). The warm conductivity of copper tube is 386 W/ mk.

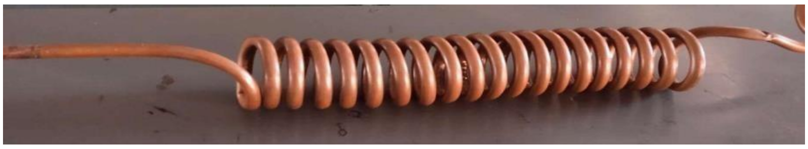

Fig. 1. Helical Coil Tube

3.3. Thermocouple

A thermocouple is a device that consists of two distinguishable channels that form electrical interconnection at different temperatures. Because of the thermoelectric generator, a temperature sensor produces an atmospheric pressure voltage, which can be decrypted to determine temperature. Thermocouples are widely used in various types of temperature sensors. When various metals are joined at the shutdowns and there is a temperature difference between it joints, a wanted to attract is observed, which is known as temperature. The wanted to attract observed was later demonstrated to be expected to temperature fluid velocity. In practice, the amount of savings at a single intersection of two different types of wire can be used to calculate temperature at extreme temperatures. The magnitude of the capacitance is classified by the characteristics of wire used, and a K type temperature sensor is used in this evaluation.

3.4. Temperature Indicator

Temperature indicator removes the yield of the thermocouple with high exactness and it is customizable from J to K sort thermocouple readings. It needs electrical stock and shows in computerized structure. The most extreme temperature faculties about 1200ºC. It likewise faculties consequently the sort of thermocouple gets associated with the circuit. It additionally has RLY signal which gets informs the precise temperature when it gets ON state. It achieves the ON state when the client setting temperature more than the thermocouple detecting temperature.

4. Nanofluids

4.1. Nanofluids

Nanofluid has been created in 1995 by US CHAI. In the nanofluid warm conductivity, thickness and consistency has been expanded and explicit warmth has been diminished in (MWCNT)nanofluids. In 100ml of water(50-80nm) MWCNT has been added. It has been considered for applications as cutting edge heat move liquids for very nearly two decades. High explicit surface region and in this manner more warmth move surface among particles and liquids. High scattering soundness with prevalent Brownian movement of particles. A wide assortment of mechanical cycles includes the exchange of warmth energy. All through any modern office, heat should be added, taken out, or moved from one interaction stream to another and it has become a significant errand for modern need. These cycles give a source to fuel recuperation and cycle liquid warming/cooling. The improvement of warming or cooling in a modern cycle may make a saving in energy, diminish measure time, raise warm appraising and extend the working existence of gear. A few cycles are even influenced subjectively by the activity of upgraded heat move. The advancement of elite warm frameworks for heat move upgrade has become mainstream these days. A significant amount of work has been done to gain an understanding of the heat move advancement for their rational thought application to warm exchange update. As a result of the approach of giving excellent broadcast measures, there has been a crucial demand for new developments to improve thermal push. There are a few methods for increasing the effectiveness of the warmth move. Several strategies include the use of enlarged surfaces, when compared to the warm 8 conductivity of solids, commonly used warmth move liquids like water, propylene glycol, and hydraulic fluid have generally low warm conductivities. By adding small large and powerful particles to a liquid with a high warm diffusivity of solids, the warm capacitance of that fluid can be increased.

4.2. Stability Mechanism of Nanofluids

Particles in scattering may follow each other and formation totals of expanding size may settle out due to gravity. Dependability denotes that the particles do not accumulate at a rapid rate. The rate of total is determined by the frequency of collisions and the likelihood of adhesion during impact on a daily basis. If the alluring power is greater than the terrible power, the two are equal. If the particles experience a sufficiently high shock, the suspensions will exist in a stable state. The dreadful powers between particles should be dominant in stable nanofluids or colloids. According to the types of aversion, the central components that influence colloidal stability are divided into two types: steric repugnance and electrostatic (charge) shock. Silver nanofluids are completely stable due to PVP's defensive role, which prevents the development and agglomeration of nanoparticles via steric impact. Surface charge will be generated for electrostatic adjustment via at least one of the following systems: wide range of particle adsorption, disconnection of surface charged species, isomorphic renewal of particles, amassing or energy usage of charged particles at the surface, and actual absorption of charged particle onto to the top layer.

4.3. Stability of Nanofluids

The agglomeration in nanostructures causes not only the resolution and closing of small channels, but also a decrease in the thermal conductivity. As a result, the examination of dependability is a major question that influences the properties of composites for application, and it is critical to consider and break down influencing elements to the scavenger. This section will include (a) strategies for assessing the stability of nanofluids, (b) methods for improving the security of hybrid nanofluid, and (c) nanofluid dependability elements.

4.4. Multiwall Carbon Nanotube

Multi-walled nanotubes (MWNTs) comprise of various moved graphene strands (concentric containers). To depict the constructions of multi-walled nanotubes, two models can be used. Sheets of graphite are orchestrated in concentric chambers in the Russian Doll model. A staying calm of graphite is brought around in on its own in the Parchment model, giving it the appearance of content or moved paper. In multi-walled nanotubes, the impact strength is similar to the distance between molecular chains in carbon fibre. Individual CNT shell strength is amazingly high; however, frail frictional collaborations between habitable shells and cylinders result in a critical decrease throughout the compelling toughness of intra nanoparticles. Carbon nanotubes with multiple layers are expected to be excellent warm conductors along the cylinder, exhibiting a giving knowledge as "ballistic energy transfer," but with great encasings horizontally to the cylinder hub. A carbon nanotube's width can be several times that of a human hair, but it is more grounded than steel per unit weight.

5. Experimental Setup

5.1. Experimental Setup

Supply which fills in as an essential gadget all the while and it has a channel, outlet. The limit of the repository is around 5 liters by which supply of the liquid to the copper cylinder and re-course happens. The channel is associated with the siphon delta and foot valve is additionally used to suck the coolant, this go about as a bay association. The power source of the siphon is constrained by the ball valve and gets associated with the half inch hose pipe. The line is plainly obvious for the liquid stream and further the line gets converged with channel of the copper tube which additionally contains the bay of the constrain check and thermocouple to quantify the pressing factor and temperature readings separately. The copper tube which is kept inside the barrel shaped glass tube involves the breadth around 10 cm. The glass is a type of secured layer for the copper tube and ingest the solar powered radiation followed by communicating to the copper tube. In this way the warmth move upgrade happens inside the glass and the power source of the copper tube is associated with the one finish of pressing factor measure. Pressing factor check is additionally faculties the power source pressing factor of the coolant utilized for the examination. While the power source is converged with the outside outlet thermocouple to examine the temperature of the power source liquid is trailed by hose pipe. The hose pipe further holds some length to interface with the supply for the re-flow measure and the liquid passing in the cylinder constantly with no pressing factor drop. Hence some vibration is provided with 3v dc motor since it increases the conductivity of the experiment.

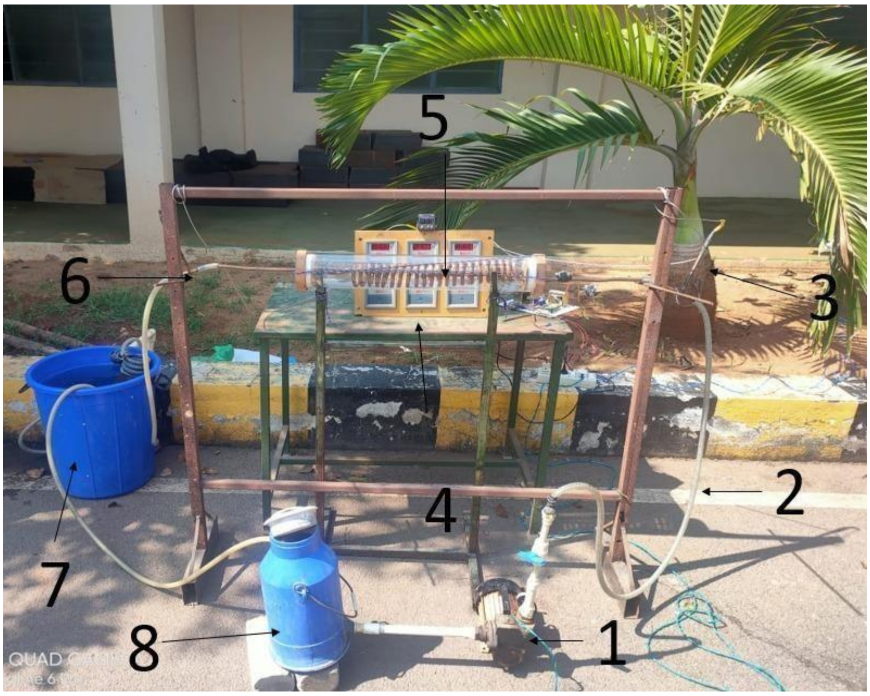

Fig. 2. Experimental setup
(1) Pump **(2)** Tube **(3)** Inlet Thermocouple[T1] **(4**) Temperature indicator
(5) Collector **(6)** Outlet Thermocouple[T2] **(7**) Radiator **(8)** Reservoir (Nano fluid)

5.2. Deionised Water as Working Medium

Deionised water is used as the working medium in the initial stage to propagate the conductivity of the heat from the collector. Hence it is better in conductivity when compared with the water.

Here T1 as an Inlet Temperature T2 as an Outlet Temperature T3 as an Inner Temperature

TIME	T1	T2	T3
10	31	40	37
10.15	33	41	40
10.3	34	42	41
10.45	33	44	42
11	34	45	44
11.15	34	47	43
11.3	34	48	45
11.45	35	51	45
12	33	54	47
12.15	33	55	47
12.3	34	56	46
12.45	34	55	48
1	34	55	47
1.15	33	52	46
1.3	34	53	44
1.45	34	53	45
2	35	52	45
2.15	35	53	45
2.3	34	52	44
2.45	34	52	45
3	35	51	47
3.15	33	50	46
3.3	34	49	45
3.45	34	48	44
4	35	47	45

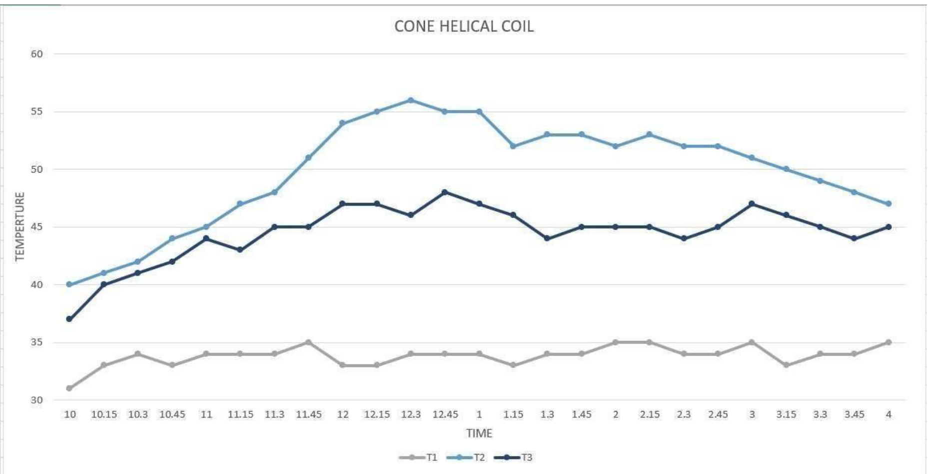

Fig. 3. Experiment with Deionised Water

5.3. Nanofluids as Working Medium

The experiment is conducted for four consecutive days to have a better analysis of the nanofluid medium for the conductivity of the heat.

TIME	T1	T2	T3
10	31	41	37
10.15	31	42	39
10.3	32	43	39
10.45	32	45	41
11	33	47	44
11.15	34	47	42
11.3	33	47	43
11.45	33	51	45
12	34	53	47
12.15	33	52	47
12.3	34	55	46
12.45	34	53	46
1	34	55	45
1.15	33	52	44
1.3	34	51	43
1.45	34	51	43
2	35	52	44
2.15	35	52	45
2.3	34	51	44
2.45	34	54	46
3	35	51	45
3.15	34	52	46
3.3	33	53	47
3.45	34	50	46
4	34	49	45

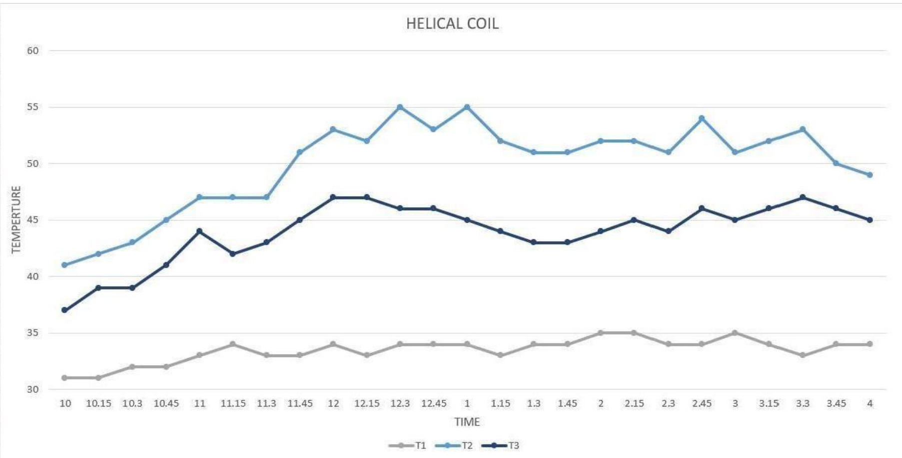

Fig. 4. Day 1

TIME	T1	T2	T3
10	31	40	36
10.15	31	43	38
10.3	32	44	39
10.45	32	43	41
11	33	46	44
11.15	34	48	42
11.3	33	48	43
11.45	33	51	45
12	34	53	47
12.15	33	52	47
12.3	34	55	46
12.45	34	53	46
1	34	55	45
1.15	33	52	44
1.3	34	51	43
1.45	34	51	43
2	35	52	44
2.15	35	52	45
2.3	34	51	44
2.45	34	54	46
3	35	50	45
3.15	34	51	46
3.3	33	52	46
3.45	34	49	45
4	34	48	44

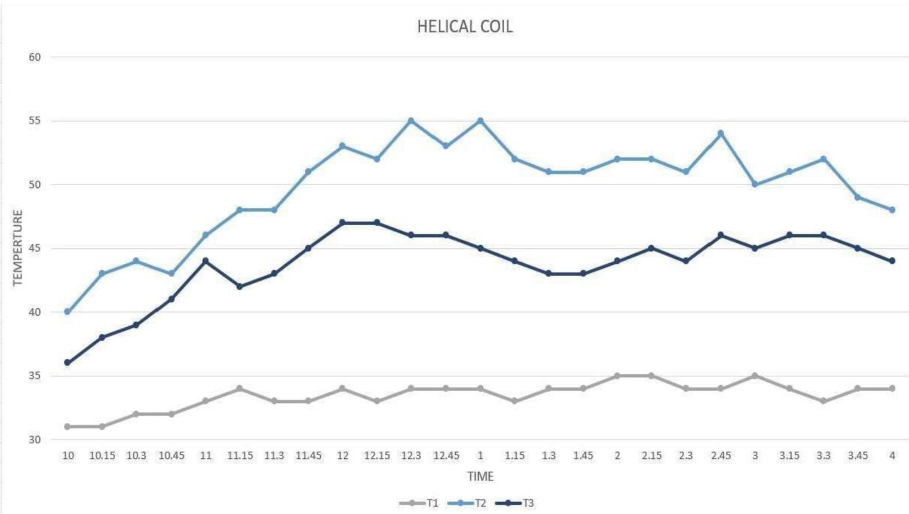

Fig. 5. Day 2

TIME	T1	T2	T3
10	31	42	36
10.15	31	42	38
10.3	32	43	39
10.45	32	44	41
11	33	45	44
11.15	34	48	42
11.3	33	48	43
11.45	33	51	45
12	34	53	47
12.15	33	52	47
12.3	34	54	46
12.45	34	53	46
1	34	55	45
1.15	33	52	44
1.3	34	51	43
1.45	34	51	43
2	35	50	44
2.15	35	52	45
2.3	34	51	44
2.45	34	54	46
3	35	50	45
3.15	34	50	46
3.3	33	53	46
3.45	34	48	45
4	34	48	44

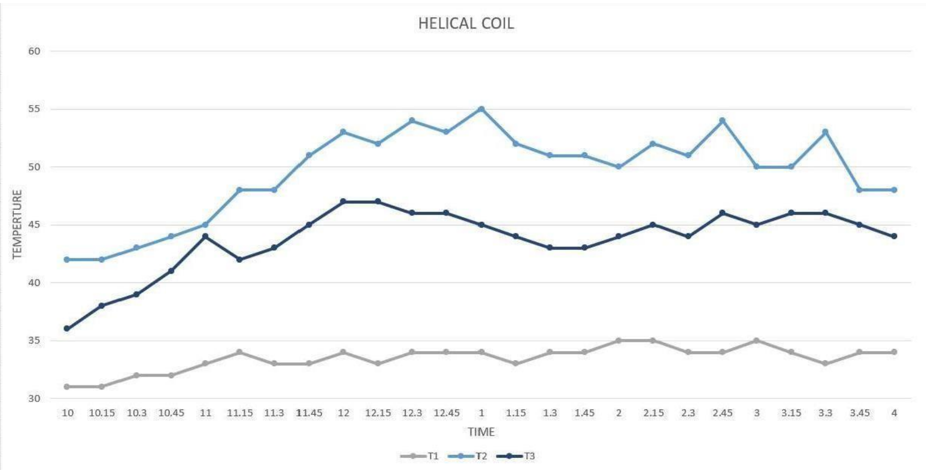

Fig. 6. Day 3

TIME	T1	T2	T3
10	31	41	37
10.15	31	40	38
10.3	32	44	39
10.45	32	44	41
11	33	46	43
11.15	34	48	42
11.3	33	48	43
11.45	33	51	45
12	34	52	47
12.15	33	52	47
12.3	34	55	46
12.45	34	53	46
1	34	55	45
1.15	33	50	44
1.3	34	51	43
1.45	34	51	43
2	35	50	44
2.15	35	52	45
2.3	34	51	44
2.45	34	54	46
3	35	50	45
3.15	34	52	45
3.3	33	51	45
3.45	34	48	44
4	34	47	43

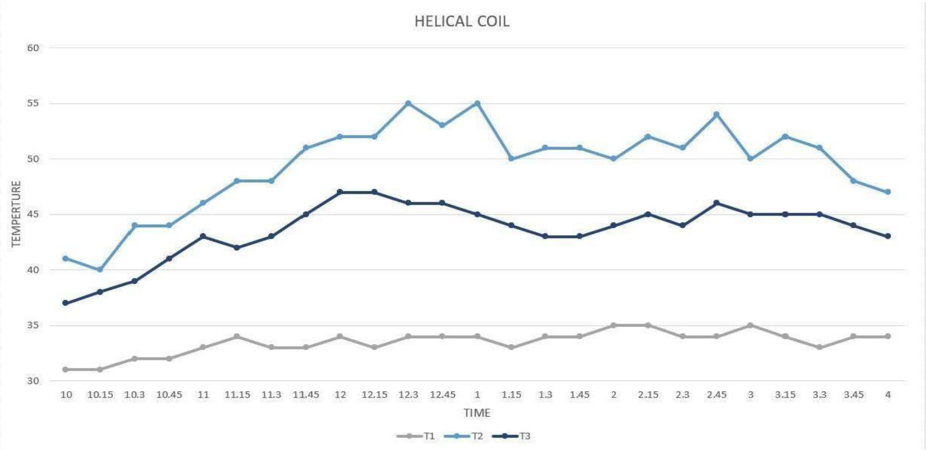

Fig. 7. Day 4

5.4. Heat Transfer Enhanced

The experiment is conducted for four consecutive days to have a better analysis of the nanofluid medium for the heat transfer enhanced.

TIME	Q1	Q2	Q3	Q4
10	1155	1270.5	1270.5	1155
10.15	1270.5	1386	1270.5	1039.5
10.3	1270.5	1386	1207.5	1386
10.45	1501.5	1270.5	1386	1386
11	1617	1501.5	1386	1501.5
11.15	1501.5	1617	1617	1617
11.3	1617	1732.5	1732.5	1732.5
11.45	2079	2079	2079	2079
12	2194.5	2194.5	2194.5	2079
12.15	2194.5	2194.5	2194.5	2194.5
12.3	2425.5	2425.5	2310	2425.5
12.45	2194.5	2194.5	2194.5	2194.5
1	2425.5	2425.5	2425.5	2425.5
1.15	2194.5	2194.5	2194.5	1963.5
1.3	1963.5	1963.5	1963.5	1963.5
1.45	1963.5	1963.5	1963.5	2079
2	1963.5	1963.5	1963.5	1732.5
2.15	1963.5	1963.5	1963.5	1963.5
2.3	1963.5	1963.5	2310	1963.5
2.45	2310	2310	1732.5	2310
3	1848	1732.5	1848	1732.5
3.15	2079	1963.5	2310	2079
3.3	2310	2194.5	1617	2079
3.45	1848	1732.5	1617	1617
4	1732.5	1848	1597	1501.5

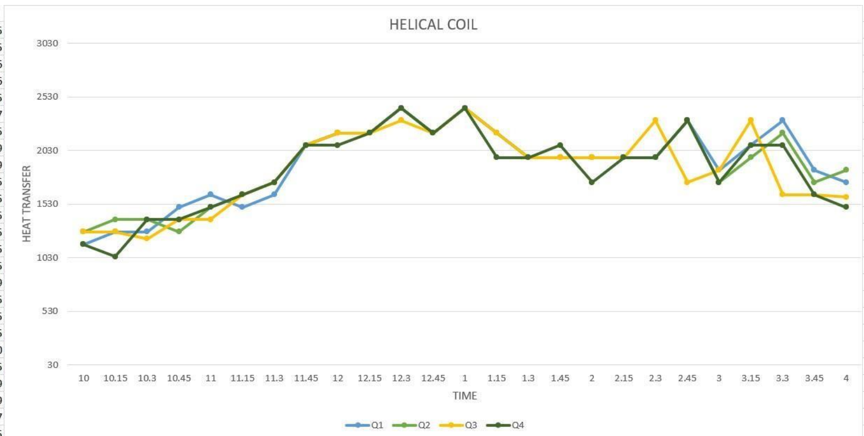

Fig. 8. Heat Transfer Enhanced

6. Conclusion

This examination explored the exhibition qualities of a nano fluid based cylindrical hollow solar light based authority with helical copper tube. The exploratory examination is completed utilizing water and MWCNT Nano fluid as the functioning liquids. A nanofluid which is a combination of refined water in the sonication cycle and afterward it very well may be utilized as the functioning liquid in the solar based authority. The outcomes exhibit that powerful sonication can essentially improve warm conductivity of nanofluids and furthermore solidness of nanofluids. The hypothetical outcomes show that the nanofluid- based barrel shaped solar authority can possibly tackle solar based brilliant energy all the more proficiently when contrasted with a level plate solar light based gatherers. By utilizing MWCNT as a functioning liquid temperature ingestion rate is about 23.56 % higher than water and furthermore the warmth move rate involves about 18.12 % expansion than the water which can be utilized as a functioning liquid. The significant rate can be examined and determined hypothetically and the qualities are plotted in the chart separately. A significant benefit of this framework is that it isn't important to guide it to the solar in view of its round shape, while the level plate authority ought to consistently be coordinated to point toward the solar with a specific shifted point to get the best productivity. Moreover, it has an extra benefit of having a lower heat misfortune since it is made out of a glass tube and a copper loop. While water can be utilized as a functioning liquid there is an event of high warmth move misfortune than nanofluid. The examination completed both hypothetically and tentatively. At last we investigated the warmth move rate can be improved by utilizing the nanofluids in any sort of warmth exchanger than different coolants.

7. Acknowledgement

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References

T. Yousefi, F. Veysi, E. Shojaeizadeh, S. Zinadini, an experimental investigation on the effect of Al2O3–H2O nanofluid on the efficiency of flat- plate solar collectors, Renew. *Energy* 39 (2012) 293–298.

Natarajan E, Sathish R. Role of nanofluids in solar water heater. *Int J Adv Manuf Technol;* 2009. doi:10.1007/s00170-008-1876-8.

R.A. Taylor, P.E. Phelan, T.P. Otanicar, C.A. Walker, M. Nguyen, S. Trimble, R. Prasher, Applicability of nanofluids in high flux solar collectors, *J. Renew. Sustain. Energy* 3 (2011). 023104-1.

Otanicar T, Phelan PE, Prasher RS, Rosengarten G, Taylor RA. Nanofluid- based direct absorption solar collector. *J Renewable Sustainable Energy* 2010; 2:033102.

L. Lu, Z.H. Liu, H.S. Xiao, Thermal performance of an open thermosyphon using nanofluids for high temperature evacuated tubular solar collectors, *Solar Energy* 85 (2011) 379–387.

R. Saidur, T.C. Meng, Z. Said, M. Hasanuzzaman, A. Kamyar, Evaluation of the effect of nanofluid-based absorbers on direct solar collector, *Int. J. Heat Mass Transfer* 55 (2012) 589– 597.

V. Khullar, H. Tyagi, P.E. Phelan, T.P. Otanicar, H. Singh, R.A. Taylor, Solar energy harvesting using nanofluids-based concentrating solar collector, in *Proceedings of MNHMT2012 3rd Micro/Nanoscale Heat & Mass Transfer International Conference* on March 3–6, Atlanta, Georgia, USA, 2012.

S. Rashidi, J.A. Esfahani, A. Rashidi, A review on the applications of porous materials in solar energy systems. *Renewable and sustainable Energy Reviews* 73 (2017)-1210.

E. Bellos, C. Tzivanidis, Enhancing the performance of a parabolic trough collector with combined thermal and optical techniques, *Appl. Therm. Eng.*164 (2020), 114498.

Y. Li, H. Xie, W. Yu, J. Li, Investigation on heat transfer performances of nanofluids in solar collector, *Mater. Sci. Forum* 694 (2011) 33–36.