

## **Experimental Study on the Effect of Surface Modification Nanofluids on Thermal Efficiency of a Solar Collector with Helical Tube**

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**Abstract:** In this experimental investigation the effect Experimental study on the effect of surface modification Nanofluid on thermal efficiency of solar collector with vibrator helical tube. The collector consists of a cylindrical glass tube with surface modified helical coil as the receiver of the solar energy. Also the efficiency with MWCNT nanofluid far from isoelectric points higher than other nanofluid. The MWCNT/water nanofluids at 0.1%, 0.3%, and 0.5% molecule volume fixations were set up with the expansion of surfactant by utilizing the two-venture strategy. It is examined that the readied MWCNT/water nanofluids show great solidness even following 45 days of planning and there is no impressive store of nanotubes on the cylinder inward divider. It is likewise contemplated that there is no impending danger of taking care of MWCNT and considered that there is no critical disintegration of wound cylinder internal divider surface even after a few trials. Thusly, the MWCNT/water nanofluids are the other warmth move liquids for conventional liquids in the helically looped tube heat exchanger to improve the warmth move with extensive pressing factor drop. Satisfactory execution of materials at raised temperatures is a possible issue in numerous frameworks inside the synthetic, petrol, cycle, and force producing enterprises. Debasement of materials happens due to connection between the primary material and the openness climate.

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**Keywords:** Nanofluid, Heat Transfer & EFFICIENCY.

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### **1. Introduction**

Heat exchangers are broadly utilized in the process enterprises for wide assortment of utilizations including steam power plants, atomic reactors, refrigeration and cooling frameworks, substance preparing, food businesses and clinical gear. Upgrade in heat move coefficient improves the exhibition of heat exchanger and lessens the size of the heat exchanger. Solar water warming frameworks, as one of the sustainable power advances utilized for the most part in private structures, can diminish the utilization of non-renewable energy sources just as related ecological issues. Since the regular solar liquids like water, ethylene glycol, and propylene glycol are powerless safeguard, adding nano particles to the functioning liquid as a retaining medium have been proposed. Since the low warm conductivity of ordinary liquids makes a sincere limit in improving the exhibition of warmth move supplies, like solar authorities, this constraint can be overwhelmed with the utilization of nanofluids. In helical coil heat exchangers coil breadth stays same, thus the force of secondaries created stays same which influences in steady warmth move coefficient. In helical coiled calculation the breadth of the coil persistently changes from deepest to the furthest area. This consistent change in width modifies the nearby warmth move coefficient from deepest to the peripheral area. The MWCNTs as the nanofluid are exceptionally retaining over most of the solar based range, considering near 100% solar powered energy assimilation, even at low focuses and little assortment volumes. Nano liquids have a lower heat limit contrasted with normal liquids, in this way the utilization of nanofluids in solar powered gatherers as the fundamental gathering of solar oriented energy gadgets prompts expansions in outlet temperature of the authority. The impact of adding surfactant with MWCNT expands the productivity up to 15%.

### **2. Literature Survey**

Ganesh Kumar Poongavanam, et al., et al., (2019) Improved heat transfer and flow characteristics of nanofluids in smooth tubes in tubular heat exchangers. Yunchan shin, et al., (2020) experiment investigation Increases in the concentration and penetration distance, Solar energy materials and solar cells (Enhancement of photo thermal energy). Ahmed Amine Hachicha, et al., (2019) experiment investigation Concentration of technologies, parabolic through solar collector and solar tower. Renewable and sustainable Energy Reviews (High temperature solar thermal collector).

R. Rajaraman, et al., (2018), experiment investigation to improved thermo physical properties and enhance heat transfer properties, to estimate the thermal properties of nano fluids. Pramod. S. Purandare, et al., (2015) experiment investigation The Nu increases with increases in re inside tube for constant outside cold water flow. (so, heat transfer co-efficient get increased). Investigation on Conical Coil Heat Exchanger. Cong Qi, et al.,

(2020) Comprehensive performance of heat exchange system is significantly increases. Efficiency improvement using nano fluid in Heat sink with Heat Circular Cylinder.

Ibrahim Halil Yilmaz, et al., (2018) experiment investigation Increases passive heat transfer enhancement and nanoparticle flows. Performance analysis of parabolic solar collector. Santhosh Bopehe, et al., (2020) experiment investigation This is encountered during converting solar energy into thermal energy. It encompasses optical losses from the reflector and heat losses through the solar receiver. Receiver for parabolic dish concentration at medium and high heat concentration. Mahmoud Mohammed abdelmagied, et al., (2020) experiment investigation Here, the Nu number friction factor, as well as effectiveness were increased.

Budi Kristiawan, et al., (2019) experiment investigation The thermocouple characteristic particularly thermal conductivity enhancement heat transfers co-efficient became better and induced Brownian and thermophoresis effect. Huseyin Kaya, et al., (2020) experiment investigation Nanofluids with blocks molded nanoparticles give higher authority proficiency than the platelets and sharp edges formed ones under a similar working condition. K. Palanisamy, et al., (2019) test examination Increases nu number. No critical store of the MWCNT on the internal surface of the cone curled cylinder even after a few test trial store of nanotubes on the inward divider. No impending danger of taking care of MWCNT.

Yijie Tong et al., (2020) analyze examination Use of nanofluids in a level plate sun powered gatherer bring about higher productivity and lower affectability to different working boundary regarding execution contrasted with water. Warm conductivity of MWCNT nanoparticles was generally higher than that of the other nanoparticles. Omar A. Hussein, et al., (2020) analyze examination Increment in nanoparticles focus improved nuclear power acquire and brought about higher liquid outlet temperature.

### 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 go 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 the copper tube is 386 W/m K.



Fig. 1. Helical coil Tube

#### 3.3. Thermocouple

A thermocouple is a device involving two unmistakable channels molding electrical convergences at differentiating temperatures. A thermocouple conveys a temperature-subordinate voltage in view of the thermoelectric effect, and this voltage can be unraveled to measure temperature. Thermocouples are comprehensively used in various sort of temperature sensor. Right when different metals are joined at the terminations and there is a temperature differentiation between the joints an appealing field is seen to this as thermo-fascination, the alluring field saw was consequently shown to be required to thermo-electric stream. In practical the voltage created at a singular convergence of two unmistakable sorts of wire can be used to evaluate

temperature at high and low temperatures. The significance of the voltage depends upon such wire used and K sort thermocouple is used in this investigation.

### 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 1200°C. 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.

### 3.5. Surface Modification

Surface adjustment is the show of changing the outside of a material by bringing physical, manufactured or natural characteristics not exactly equivalent to the ones at first found on the outside of a material. This adjustment is by and large made to solid materials, anyway it is possible to find occasions of the alteration to the outside of express liquids. The adjustment ought to be conceivable by different methodologies with the ultimate objective of changing a wide extent of properties of the surface, for instance, cruelty, hydrophilicity, surface charge, surface energy, biocompatibility and reactivity. Surface designing procedures are being utilized in the auto, aviation, rocket, power, electronic, biomedical, material, oil, petrochemical, synthetic, steel, power, concrete, machine apparatuses, development enterprises. Surface designing methods can be utilized to build up a wide reach of practical properties, including physical, compound, electrical, electronic, attractive, mechanical, wear-safe and consumption safe properties at the required substrate surfaces. Practically a wide range of materials, including metals, pottery, polymers, and composites can be covered on comparable or divergent materials. It is likewise conceivable to frame coatings of more current materials evaluated stores, multi-segment stores and so on.

### 3.6. Types of Surface Modification

Adjust the outside of a polymer compound microscopically to increase mechanical bond strength without affecting the material's shadiness, transport, or visibility.

Paints and coatings have a better surface wetting and grasp when they are applied to a clean surface.

To effectively grow the surface energy for h, functionalize social occasions (carboxyl (HOOC-), carbonyl (-C=O-), hydroxyl (HO and others) to the polymer substrate.



Fig. 2. Surface Modified coil

## 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 number of work has been performed to gain an understanding of the glow move execution for their judicious application to warm trade overhaul. In this manner the methodology of high warmth stream measures has prodded basic interest for new headways to improve heat move. There are a couple of methods to improve the glow move adequacy. A couple of techniques are use of extended surfaces, usage of vibration to the glow move surfaces, and use of smaller than usual channels. Warmth move capability can similarly be improved by growing the warm conductivity of the working fluid. Conventionally used warmth move fluids like water, ethylene glycol, and engine oil have commonly low warm conductivities, when diverged from the warm 8 conductivity of solids. High warm conductivity of solids can be used to augment the warm conductivity of a fluid by adding minimal solid particles to that fluid.

#### **4.2. Stability Mechanism of Nano Fluids**

Material in scattering may stick together and form totals of expanding size that will eventually settle out due to gravity. The particles should not accumulate at a rapid rate, according to dependability. The rehash of mishaps and the probability of association during impact are invariably orchestrated by the pace of supreme. If the enticing force is greater than the enticing power, the two particles will influence, and the suspension isn't reliable. In the event that the particles have an adequate high paralyze, the suspensions will exist in stable state. For stable nanofluids or colloids, the detestable powers between particles should be overpowering. As demonstrated by such revulsion, the central parts that sway colloidal relentless quality are disconnected into two sorts, one is steric horrendousness, and another is electrostatic (charge) shock. Silver nanofluids are totally reliable because of the monitored control of PVP, as it impedes the unforeseen development and agglomeration of nanoparticles by steric influence. PVP is a proficient master to improve the strength of graphite suspension. The steric impact of polymer dispersant is obliged by the centralization of the dispersant. For electrostatic change, surface charge will be made through at any rate one of the going with systems to be unequivocal, explicit adsorption of particles, separation of surface charged species, isomorphic replacement of particles, social event or use of electrons at the surface, and genuine adsorption of charged species onto the surface.

#### **4.3. Stability of Nanofluids**

The agglomeration of nanoparticles causes small pores to settle and plug up, as well as a decrease in the warm conductivity of nanofluids. As a consequence, evaluating sturdiness is a critical question that influences the properties of nanofluids for application, and it is critical to consider and differentiate influencing components to nanofluids' dispersing strength. This section will cover (a) consistent quality assessment methodologies for nanofluids, (b) ways to improve nanofluids' security, and (c) nanofluids' trustworthiness segments.

#### **4.4. Multi Wall Carbon Nanotube**

Multi-walled nanotubes (MWNTs) include different moved graphene layers (concentric compartments). The evolution of multi-walled nanotubes can be depicted using one of two models. Sheets of graphite are arranged in concentric chambers in the Russian Doll model. A single sheet of graphite is rolled in around itself in the Parchment model, giving it the appearance of material or moved paper. The interlayer distance in multi-walled nanotubes is close to the distance between graphene layers in graphite. The strength of individual CNT shells is incredibly high, fragile shear collaboration's between touching shells and chambers lead to basic diminishing in the convincing strength of multi-walled carbon nanotubes. Multi divider carbon nanotubes are depended upon to be superb warm conductors along the chamber, showing a property known as "ballistic conduction", however great encasings horizontally to the cylinder hub. The breadth of a carbon nanotube can be multiple times slenderer than a human hair yet a nanotube 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. 3.** Experimental Setup

(1) Pump (2) Tube (3) Inlet Thermocouple[T1] (4) Temperature indicator  
(5) Collector (6) Outlet Thermocouple[T2] (7) Radiator (8) Reservoir

## 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.

TIME	T1	T2	T3	VIBRATION (M/S) <sup>2</sup>
10	30	40	39	25.5
10.15	31	43	40	25.6
10.3	33	44	41	25.6
10.45	34	47	42	25.5
11	33	48	43	25.5
11.15	34	48	44	25.6
11.3	34	49	44	25.7
11.45	35	54	44	25.6
12	32	57	47	25.6
12.15	33	58	49	25.6
12.3	34	56	46	25.6
12.45	35	55	46	25.5
1	36	56	46	25.6
1.15	33	54	46	25.5
1.3	34	55	47	25.6
1.45	35	56	47	25.5
2	36	54	47	25.6
2.15	35	54	48	25.5
2.3	34	53	48	25.5
3	35	52	46	25.5
3.15	33	52	46	25.6
3.3	34	49	45	25.5
3.45	33	49	42	25.6
4	35	47	42	25.5

Here

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

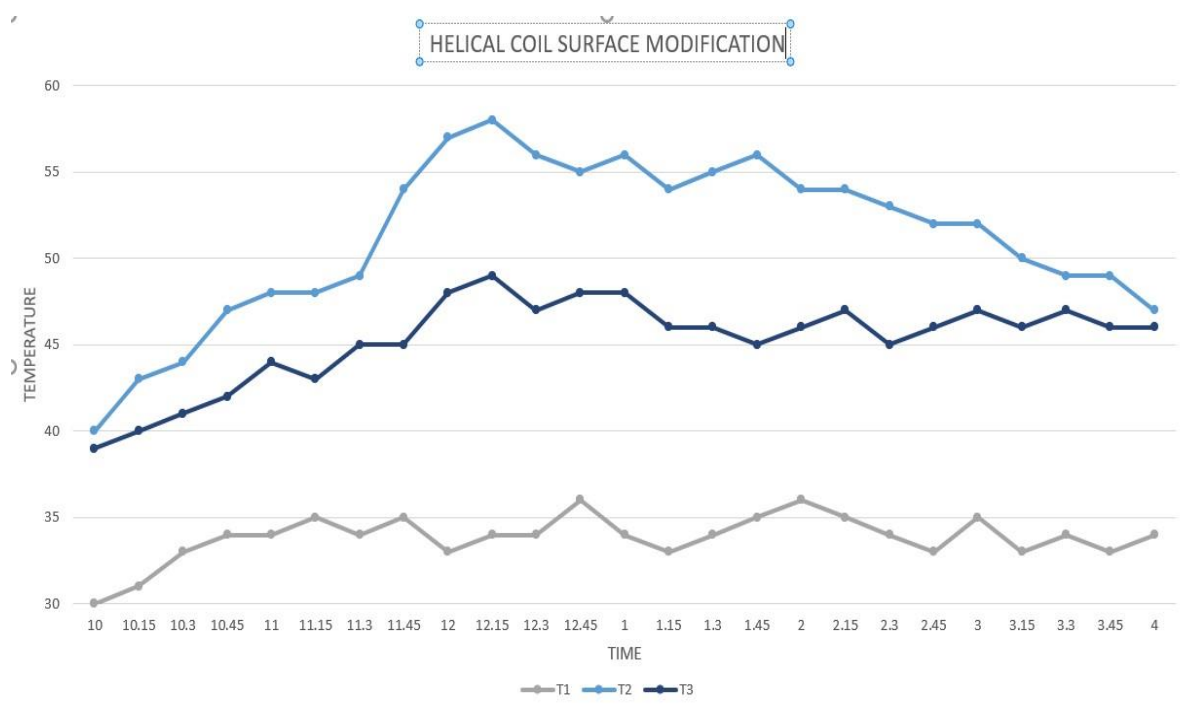


Fig. 4. Experiment with Deionised Water

### 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.

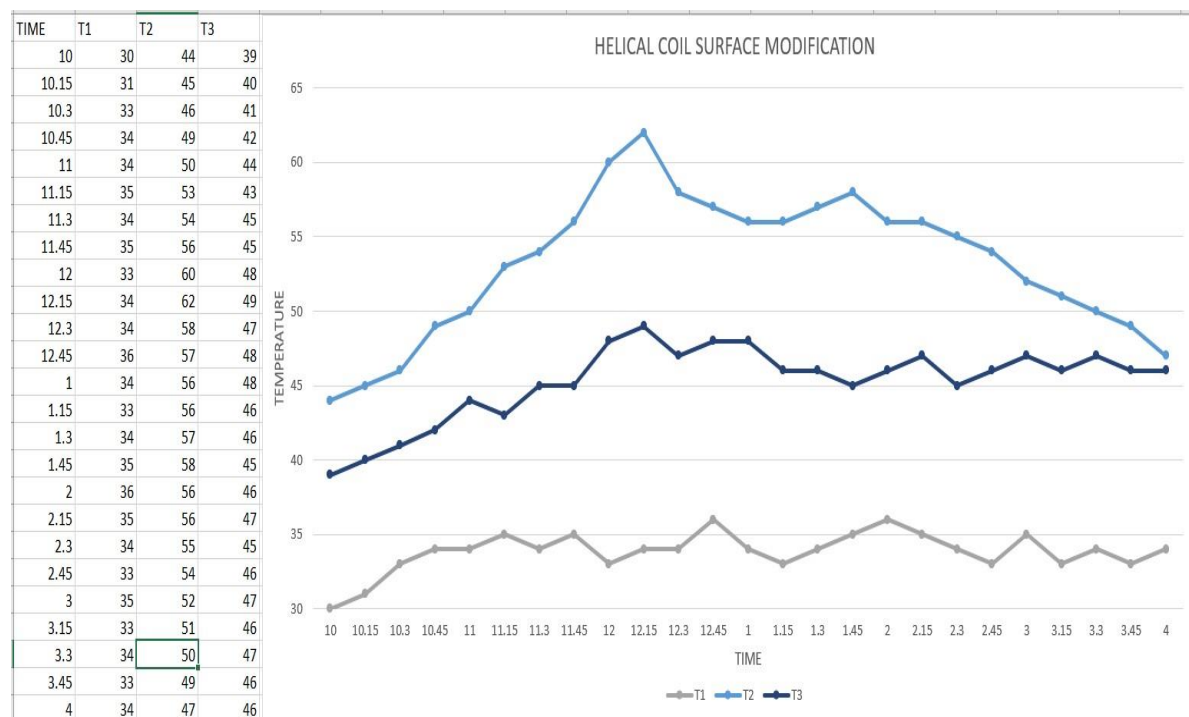


Fig. 5. Day 1

## Experimental Study on the Effect of Surface Modification Nanofluids on Thermal Efficiency of a Solar Collector with Helical Tube

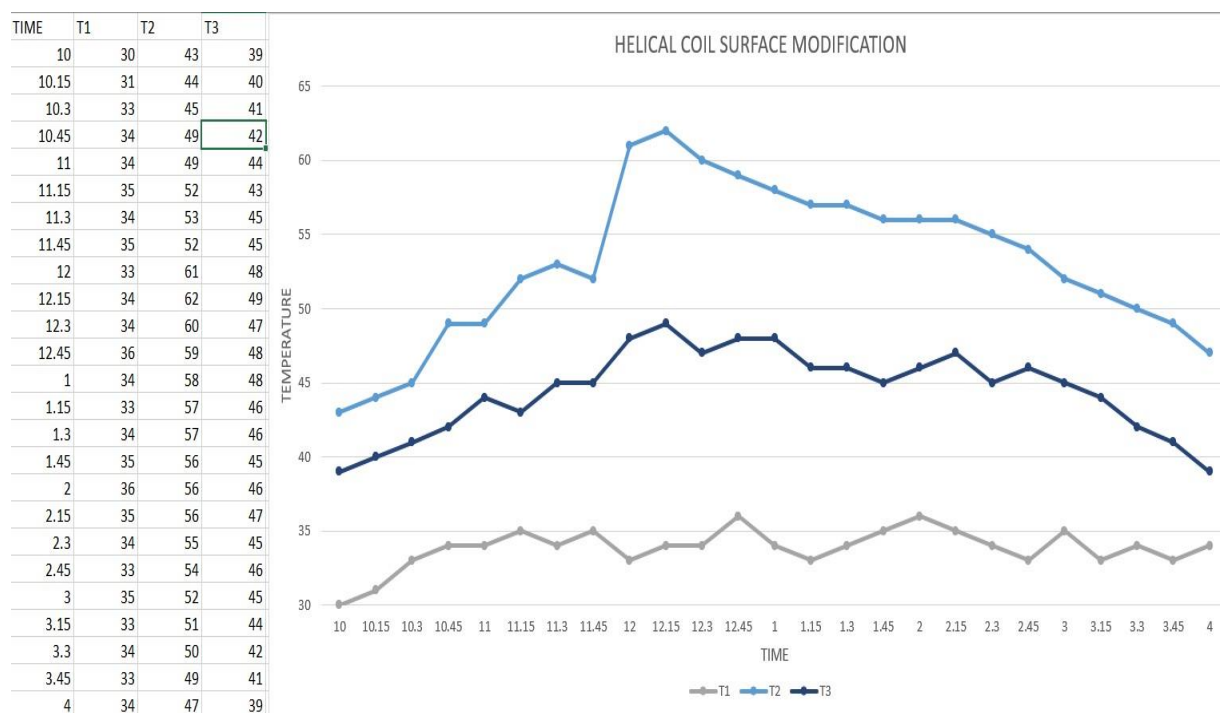


Fig. 6. Day 2

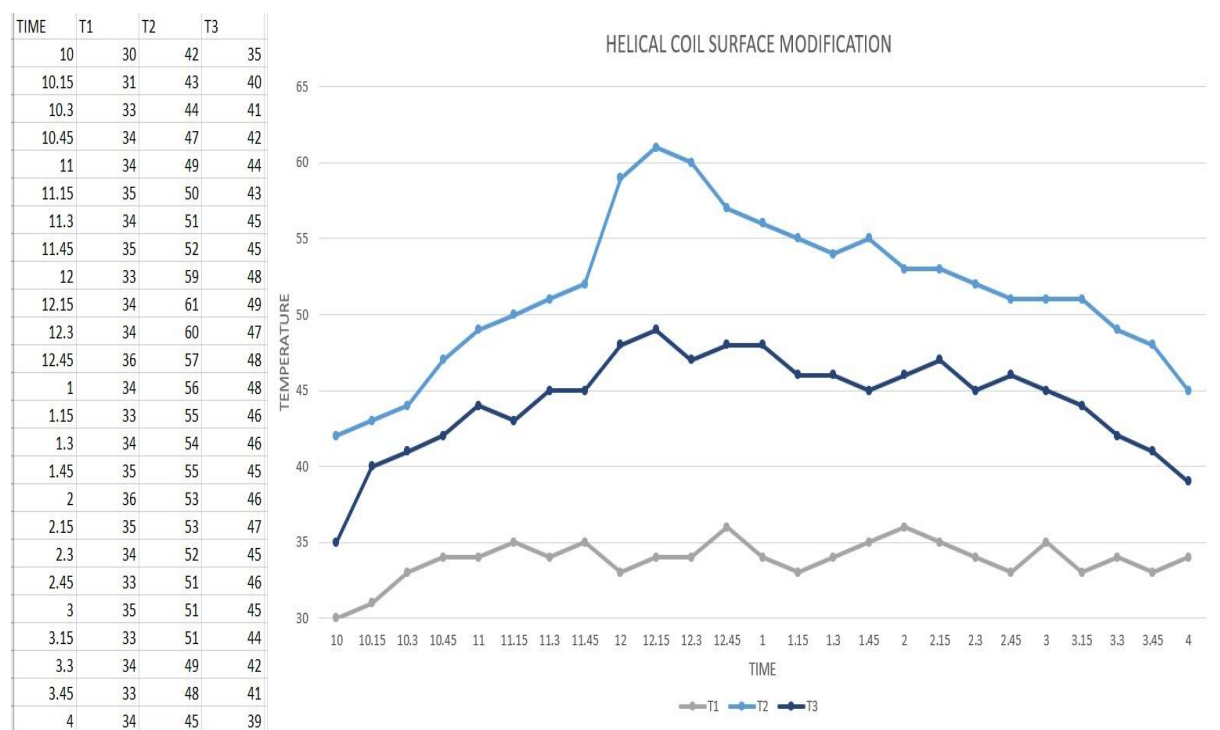


Fig. 7. Day 3

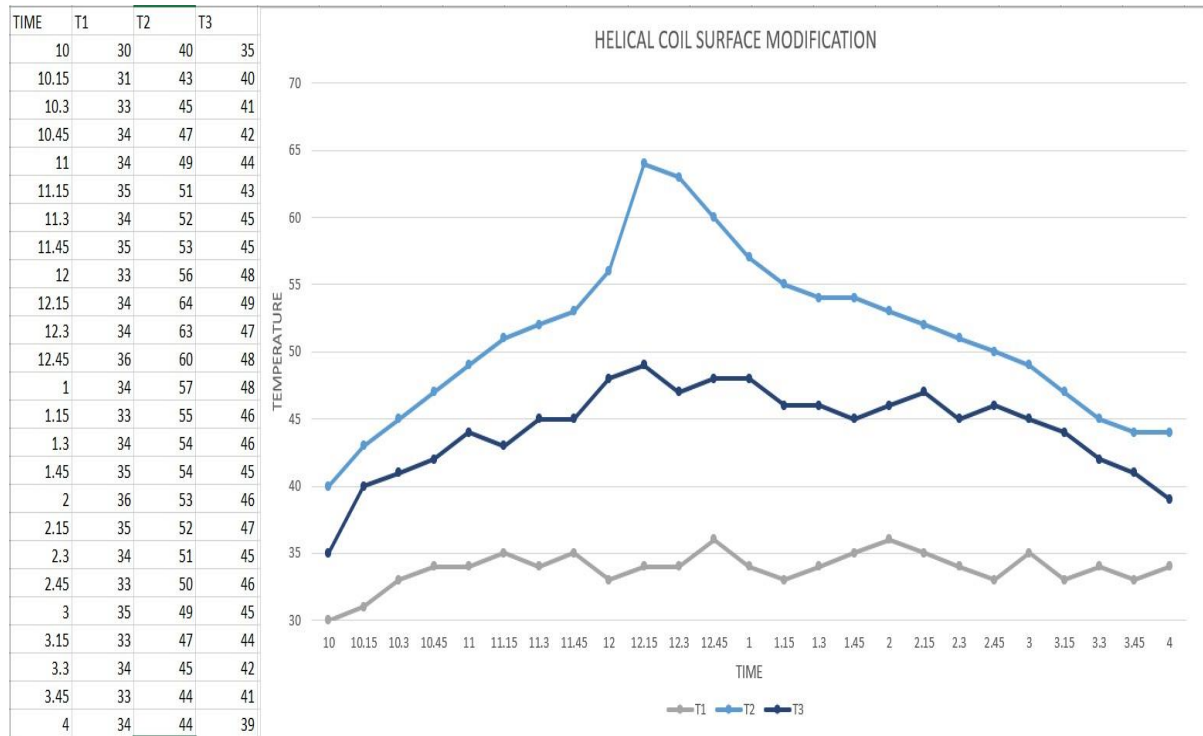


Fig. 8. Day 4

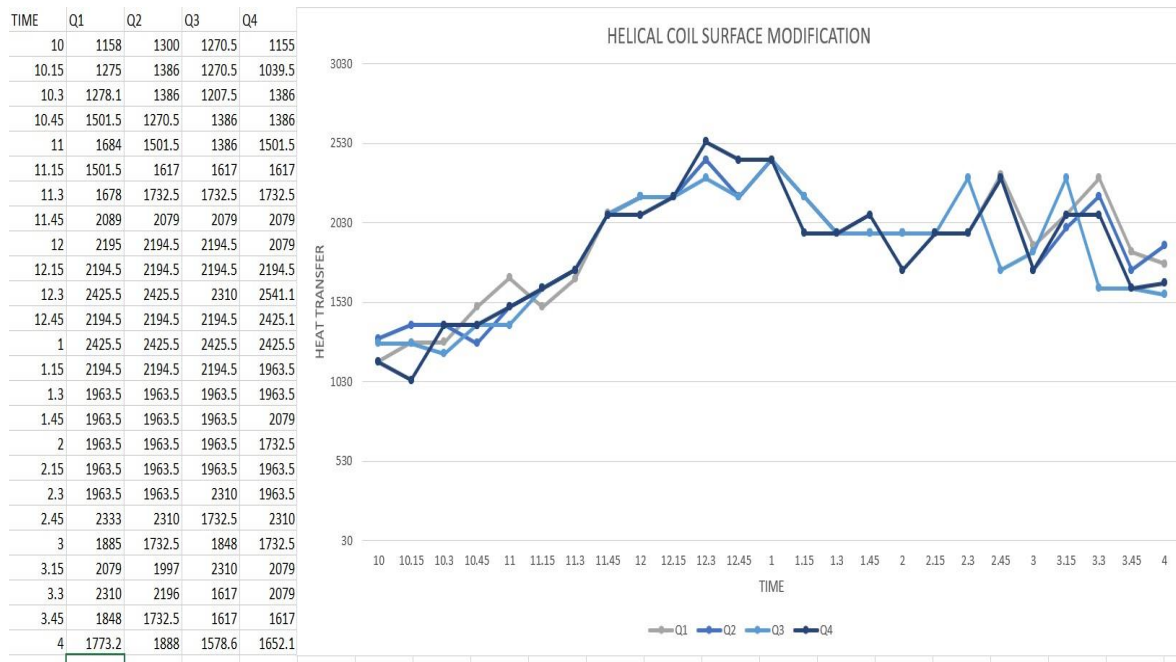


Fig. 9. Heat Transfer Enhanced

During the heat transfer the experiment is conducted for four consecutive days to have a better analysis of the nanofluid medium for the 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 nanofluid 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 29.16 % higher than water and furthermore the warmth move rate involves about 17.62 % 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.

### Acknowledgement

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### References

1. Ganesh Kumar Poongavanam, *Heat move and pressing factor drop execution of sun powered glycol/initiated carbon based nanofluid in shot peened twofold line heat exchange.*
2. Yunchan shin, et all., *Solar energy materials and solar cells (Enhancement of photo thermal energy)* (2020).
3. Ahmed Amine Hachicha, et all., *Renewable and sustainable Energy Reviews (High temperature solar thermal collector)* (2019).
4. R. Rajaraman, et all., *To estimate the thermal properties of nano fluids* (2018).
5. Yunchan shin, et all., *Solar energy materials and solar cells Increase in the concentration and penetration distance* (2020)
6. R. Pramod.S. Purandare, et all., *Investigation on Conical Coil heat Exchanger.* (2019).
7. Ibrahim Halil Yilmaz, et all., *Performance solar parabolic analysis collector.* (2018).
8. Santhosh Bopehe, et all., *Receiver for parabolic dish concentration at medium and high heat concentration.* (2020).
9. Mahmoud Mohammed abdelmagied, et all., *helical tube Thermal performance characteristics.* (2019).
10. Budi Kristiawan, et all., *Enhance the thermal performance of Water nanofluids.*