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Heat Exchange using Nanofluid in Solar Water Heating System

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***Abstract*: Nanofluids are the cooling medium of the longer term with increased thermo physical properties and warmth transfer performance is applied in seceral devices for higher performances.**

In this discusses the applying potentials of nanofluids in star water heating systems. the key part of the systems is that the solar furnace. This device absorbs the incoming radiation, changing it into heat at the gripping surface, and transfers this heat to a fluid (nanofluids or water) flowing through the collector. The warm fluid carries the warmth either on to the new water or house acquisition instrumentality or to a storage scheme from which may be drawn to be used in the dead of night and on cloudy days. The foremost efficient star heaters are of the "flat-plate" kind, however these suffer from comparatively low potency and outlet temperatures. It's been ascertained that the presence of nano particles will increase the absorption of incident radiation by quite that of pure water.

***Keywords*: Heat transfer, Solar collectors, Nanofluid.**

1. Introduction

Heat transfer sweetening in star devices is one among the key problems with energy saving and compact styles. Alternative energy is wide employed in applications like electricity generation, chemical process, and thermal heating because of its renewable and nonpolluting nature. Most star water heating systems have 2 main parts: a solar furnace and a vessel. The foremost common collector is termed a flat-plate collector however these suffer from comparatively low potency. There are numerous ways introduced to extend the potency of the star storage tank [1]-[5]. However, the novel approach is to introduce the nanofluids in solar furnace rather than standard heat transfer fluids (like water). The poor heat transfer properties of those standard fluids compared to most solids are the first obstacle to the high compactness and effectiveness of the system.

The fluids with nano sized solid particles suspended in them are known as "nanofluids." The suspended metallic or nonmetallic nanoparticles amendment the transport properties and warmth transfer characteristics of the bottom fluid. Nanofluids are the new generation heat transfer fluids for varied industrial and automotive applications thanks to their glorious thermal performance and therefore the word was that was coined at military operation National Laboratory of USA by Choi in 1995 [6], that showed that the traditional liquid thermal performance may be remarkably improved victimization nano particles. Researches in heat transfer are distributed over the previous many decades, resulting in the event of the presently used heat transfer improvement techniques. Nanofluids are often used for a good form of engineering applications like transportation, thermal management of physical science, medical, food, defense, nuclear, space, and producing of the many varieties [7]. Properly designed nanofluids possess the subsequent advantages: (i) High specific extent and so a lot of heat transfer surface between particles and fluids. (ii) High dispersion stability with predominant motion of particles, (iii) Reduced pumping power as compared to pure liquid to attain equivalent heat transfer intensification, (iv) Reduced particle obstructive as compared to convention slurries, so promoting system miniaturization, (v) Adjustable properties, together with thermal conduction and surface wet ability, by variable particle concentrations to suit totally different applications. The on top of potentials provided the thrust necessary to start analysis in nanofluids, with the expectation that these fluids can play a crucial role in developing the subsequent generation of cooling technology.

Heat transfer improvement in star devices is one in all the key problems with energy saving and compact styles. Alternative energy is wide utilized in applications like electricity generation, chemical process, and thermal heating because of its renewable and nonpolluting nature. Most star water heating systems have 2 main parts: a solar dish and a tank. The foremost common collector is named a flat-plate collector however these suffer from comparatively low potency. There are such a large amount of strategies introduced to extend the potency of the star hot-water tank [1]-[4]. However, the novel approach is to introduce the nanofluids in solar dish rather than typical heat transfer fluids (like water). The poor heat transfer properties of those typical fluids compared to most solids are the first obstacle to the high compactness and effectiveness of the system.

One of the key features for warmth transfer sweetening is that the thermal physical phenomenons, the bulk of the studies [8-14] have mentioned the thermal physical phenomenon of nanofluids. All experimental

Results [15]-[17] have implied the spectacular improvement of thermal physical phenomenon by using nano particle. The addition of alumina particles were according to boost the ensuing thermal conductivities of base fluids by up to thirtieth at particle volume fraction of Al2O3 of fifty [8, 9], four [10] or three [11].

2. Nanofluids formulation

Though numerous aspects of nano particles are extensively investigated over the past few decades; very little attention has been paid to the formulation of nanofluids, i.e. the creating of stable nano particle suspensions appropriate for warmth transfer applications. The properties and behavior of nanofluids a lot of rely upon the properties of the bottom liquid and also the distributed phases, particle concentration, size and morphology, moreover because the presence of dispersants or surfactants (called stabilizer generally in following sections). Formulation of stable nano particle suspensions has been wide practiced within the mixture business, and even in history, variety of ultrafine particles like carbon and gold were distributed into liquid media for painting and glass coating. However, the need of nanofluids formulation is a lot of hard to please than typical colloids because of the tough application setting, i.e. usually underneath high shear and hot temperature conditions. Formulating stable nanofluids, with controlled properties like thermal conduction, body and wet ability for warmth transfer applications, still presents a challenge for the nanofluid community. 2 ways will be usually used for such formulation, namely, the top-down methodology through size reduction (the ballroom dance method), and also the bottom-up approach through coincidental production and dispersion of nano particles (the ballroom dancing method).

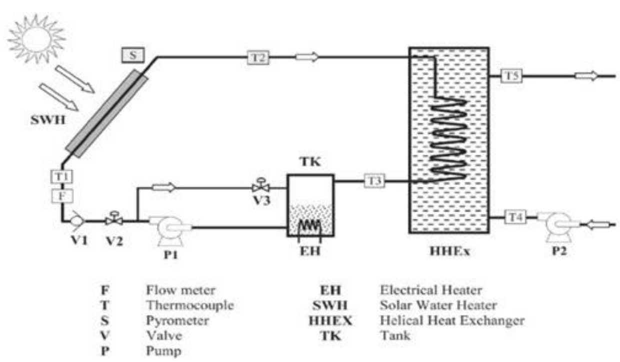

Fig. 1. Solar water heating system

A. *The two-step method*

For the ballroom dance technique, dried nano particles must be either synthesized or purchased within the variety of dry powders. Nano particles synthesized through completely different routes have different morphologies, structures and thence completely different physical and chemical properties, which is able to have an effect on the standard of the ultimate nanofluids. Presently a good vary of vapor, liquid and mechanical routes are offered for synthesizing nano particles. The mechanical route, like edge and grinding, is simple however energy intensive. The liquid route like the sol–gel and wet chemical strategies sometimes involves chemical reactions of some reagents with one desired product whereas commonly manufacturing different impurities that are tough to manage. The vapor-phase route involves producing a reactive vapor within which nucleation and growth occur through combustion, pyrolysis, plasmas, optical device ablation, optical device transformation, or chemical vapor deposition. From each economic and quality issue, the gas section route has become the foremost favorable technique for giant scale production of nano particles. Because of robust Vander Waals force, however, nearly all nano particles are within the variety of dried agglomerates with a lot of larger dimensions than the first particles. The degree of agglomeration changes with the character of the producing, handling and storage method. As a consequence, careful choice of synthesis strategies and correct characterization of as-received dried nano particles are Compared to the bottom-up approach, dispersing dry particles into liquids has been additional oftentimes utilized by researchers within the nanofluid field. it's essential to disperse giant agglomerates of nanoparticles to their primary particle size to formulate a stable dispersion. The method, by that particles are distributed within the liquid, plays a important role for adequate dispersion beneath the thermal and hydraulic conditions obligatory thereon. The final instrumentation employed in dispersing dried nanoparticles includes unhearable baths, magnetic stirrers, high-shear mixers, homogenizers and bead mills. The time interval and intensity may considerably influence the dispersion result. Weak secured agglomerates may typically be broken to the first sizes by high shearing; although nanoparticles tend to re-agglomerate because of the enticing London vander Waals force.

B. *Collector corresponding equations*

To calculate the performance as instantaneous efficiency use following equation.

$$Q_u = \dot{m}C_p(T_o - T_i)$$

$$Q_u = A_c F_R[G_T(\tau\alpha) - U_L(T_i - T_a)]$$

Where Q_u is the rate of useful energy gain (W), ṁ is the mass flow rate (Kg/s), C_P is the heat capacity of the coolant such as water or nanofluid (J/kg K), T_o is the outlet fluid temperature of solar collector (K), A_c is the surface area of solar collector (m^2), FR is the heat remove factor, (τα) is the absorption-transmittance product, G_T is the global solar radiation (W/m^2), U_L is the overall loss coefficient of the solar collector (W/m^2 K), and T_i and T_a are the inlet fluid temperature of the solar collector (K) and the ambient temperature (K) respectively.

The heat capacity of nanofluid determined by equation 4 [23], [25], [26].

$$C_{p,nf} = C_{p,np}(\varphi) + C_{p,bf}\,(1 - \varphi)$$

Where $C_{P.\,n\,p}$ is the heat capacity of nano particles (for SiO_2 is 765 J/kg K), φ is the volume fraction of nano particles and $C_{p\cdot bf}$ is the heat capacity of water as the base fluid (4180 J/kg K) [29]. The instantaneous collector efficiency is calculated by

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relation between useful energy gained to the incident solar energy through the equation 5 and 6.

$$\eta_i = \frac{Q_u}{A_c G_T} = \frac{\dot{m} C_p (T_o - T_i)}{G_T}$$

$$\eta_i = F_R(\tau\alpha) - F_R U_L \left(\frac{T_i - T_a}{G_T}\right)$$

If the collector tested near the normal incident conditions, then $F_R U_L$ and $F_R(\tau\alpha)$ are constant for the range temperatures tested. According to equation 6, a straight line would be resulted when the efficiency values obtained from the averaged data plotted against (Ti – Ta)/GT. In this line, $F_R(\tau\alpha)$ is the intersection of the line with vertical axis. This point indicates the maximum value of efficiency occurring when the inlet fluid temperature of the collector is equal to the ambient temperature. The line slope is equal to $F_R U_L$ showing the energy loss from the solar collector. The intersection of the line with horizontal axis is called stagnation point. At this point, the efficiency of the collector is zero happening when no fluid flows via the collector.

3. Possible application in solar water heating systems

Natarajan [18] has investigated the thermal physical phenomenon sweetening of base fluids victimization carbon nanotubes and recommended if these fluids are used as a heat transport medium, it will increase the potency of the traditional star warmer.

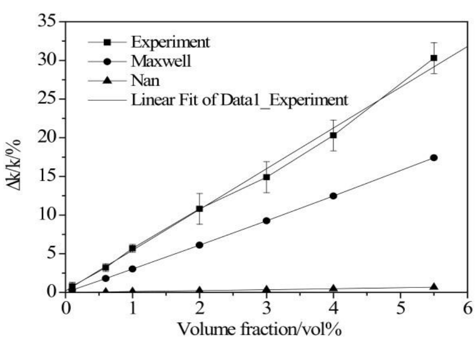

Fig. 2. Thermal conductivity enhancement versus volume fraction [18]

Tyagi et al. [5] has studied in theory the aptitude of employing a non-concentrating direct absorption solar furnace and compared its performance thereupon of a standard flat-plate collector. It absolutely was found that, with all alternative parameters like particle volume fraction, collector height, and collector length being constant, the collector potency raised slightly with AN increase within the particle size, as may be simply ascertained from Fig. 3. underneath traditional operative conditions, with D=5 nm and a particle volume fraction, φ=0.8%, the collector potency was found to be concerning seventy-three [5]. Fig. 4, shows the variation in collector potency as a perform of the particle volume fraction. The particle volume fraction was varied within the vary zero.1% to concerning 5% in these calculations. As may be ascertained from this figure, the collector potency will increase rapidly with volume fraction and tends to succeed in a most price of around eightieth close to the higher limit [5].

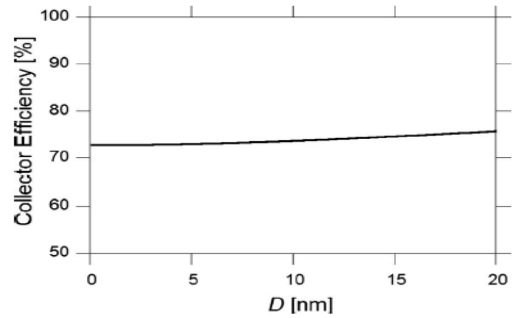

Fig. 3. Collector efficiency versus particle size [5]

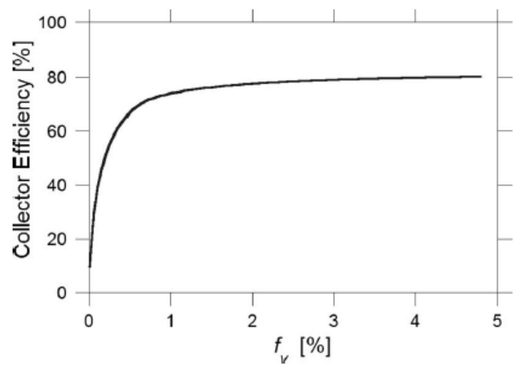

Fig. 4. Collector efficiency versus particle volume fraction [5]

Otanicar [19] has considered natural and monetary impact of utilizing nanofluids to upgrade sun oriented gatherer proficiency in contrast and regular sun powered authorities. Otanicar [20] has contemplated tentatively the impact of various nanofluids on the productivity of the smaller scale sun based warm authority. He detailed an effectiveness improvement up to 5% in sun powered warm gatherers by using the nanofluids as the assimilation medium.

Yousefi et al. [21] tentatively researched the impact of Al2O3 nanofluid in level plate sunlight based water radiator and detailed that utilizing the surfactant the greatest improved proficiency is 15.63%. Utilizing of Al2O3 nanofluid positively affected the productivity of the level plate sun based authority. The nanofluid is set up at 0.4 wt% of Al2O3 nano particles in the twofold refined water as base liquid with including Triton X-100 as surfactant. The effectiveness of the level plate sun oriented gatherer for two circumstances (utilizing the 0.4 wt% Al2O3 nanofluid with and without surfactant) and for different mass stream rates versus the decreased temperature parameters, (Ti - Ta)/GT, is appeared in Fig. 5 and Fig. 6.

Yousefi et al. [22] tentatively explored the impact of pH variety of MWCNT– H2O nanofluid on the effectiveness of a level plate sun powered authority and demonstrated that by the more contrasts between the pH of nanofluid and pH of isoelectric point causes the greater upgrade in the proficiency of gatherer. Fig. 8(a) and (b) demonstrates that how the retained vitality parameter and expelled vitality parameter of the sun based gatherer shift with pH esteems.

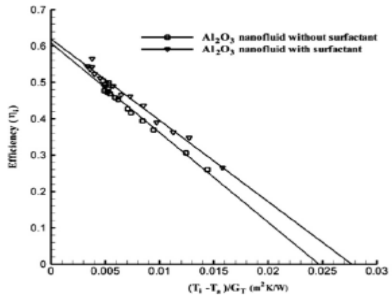

Fig. 5. The efficiency of the flat-plate solar collector for 0.4 wt% Al_2O_3 nanofluid with and without surfactant [21]

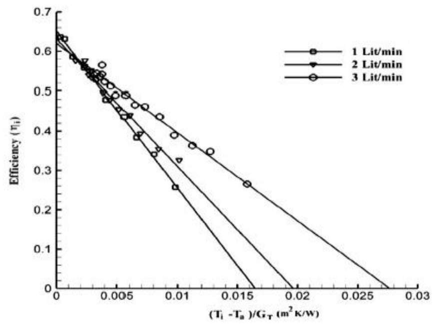

Fig. 6. The efficiency of the flat-plate solar collector with Al_2O_3 nanofluid as base fluid for various mass flow rates. [21]

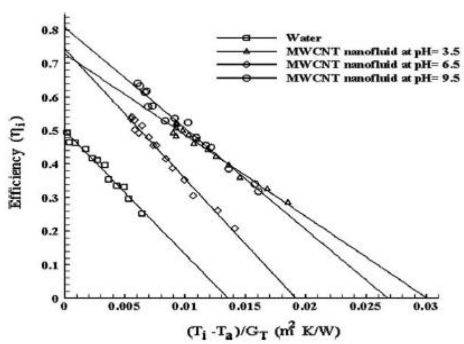

Fig. 7. The efficiency of the flat-plate solar collector with MWCNT nanofluid as base fluid at three pH values as compared with water [22]

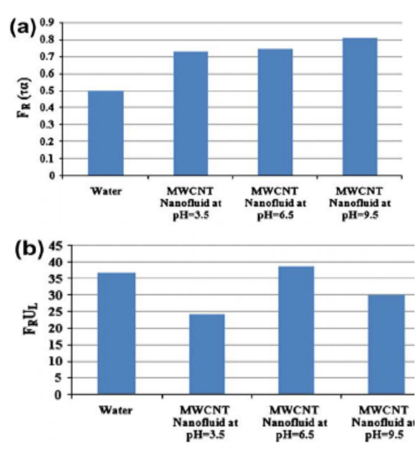

Fig. 8. FR $\tau\alpha$ and FRUL of the flat-plate solar collector for water and nanofluids with various pH values [22]

4. Conclusion and Discussion

Sun oriented vitality has the best capability of the considerable number of wellsprings of sustainable power source particularly when different sources in the nation have exhausted. There are number of strategies acquainted with increment the execution of the sun powered water warming framework. In any case, the novel methodology is to present the nanofluids in sunlight based water warmer rather than traditional warmth exchange liquids. Exhibitions of sun oriented water warming framework can be improved by utilization of nanofluids. On the off chance that these liquids are utilized as a warmth transport medium, it builds the proficiency of the conventional sunlight based water radiator.

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