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Performance of Natural Circulation Loop Using Distilled Water and Aluminum Oxide as a Nano Fluid

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Abstract- The main advantage of the natural circulation system is that the heat transport function is achieved without the aid of any pump. The absence of moving/rotating parts to generate the motive force for flow makes it less prone to failures reducing the maintenance and operating costs. The motive force for the flow is generated within the loop simply because of the presence of the heat source and the heat sink. A large variety of combinations of nanostructures and heat transfer fluids can be used to synthesize stable nanofluids with improved thermal transport properties. Nanostructures made from metals, oxides, carbides and carbon nanotubes can be dispersed into HTFs, such as water, ethylene glycol, hydrocarbons and fluorocarbons with or without the presence of stabilizing agents. In most experimental studies, nanofluids are synthesized in a two-step process, which are the first and the most classic synthesis method of nanofluids. In the present work nanoparticles of ZnO, CuO and Al2O3 were orchestrated. These integrated nanoparticles were then portrayed by utilizing different procedures like X-ray diffraction (XRD), transmission electron microscopy (TEM), scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX).

Keywords:- X-ray diffraction,transmission electron microscopy, scanning electron microscopy and energy dispersive X-ray spectroscopy.

I. INTRODUCTION

Natural circulation loops (thermosyphons) are stream systems heated from beneath and cooled from above, with the end goal that the heat sink is higher than the heat source. This particular arrangement makes a thickness slope which creates the main impetus.

Thermosyphons show up in geophysical and geothermal systems and have been utilized in numerous applications in differing vitality change systems, for example, solar heating gadgets, ingestion iceboxes, reboilers in concoction ventures and cooling of different motors. One of the most significant employments of thermosyphons is in crisis center cooling of atomic reactors.

This subject increased more enthusiasm following the recuperation of the reactor after the Three Mile Island (TMI) mishap in 1979, when it was shown that natural circulation was the main compelling approach to evacuate the rot heat.

Natural circulation flows are regularly isolated into single-and two-stage loops. Hypothetical strategies have been created so as to recreate different loops, infer scaling laws for tests and clarify physical marvels including security attributes. The numerical models depend on the coupled preservation conditions, rendering the issue nonlinear. The

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progression condition in one-dimensional models yields the outcome that the speed, v, is an element of time in particular (and an obscure consistent for steady state).

The temperature dispersion, T, is gotten as far as v by comprehending the vitality condition. For two-stage loop areas the quality, x, is gotten and for twofold diffusive loops the saltiness, S, is found from the dissemination condition.

The energy condition is incorporated along the shut loop; to yield v. Systematic arrangements exist for basic loops. Numerical techniques are required for progressively complex ones and for transient estimations. Security highlights have been gotten by direct solidness examination just as by limited sufficiency strategies; numerical arrangements are utilized for both.

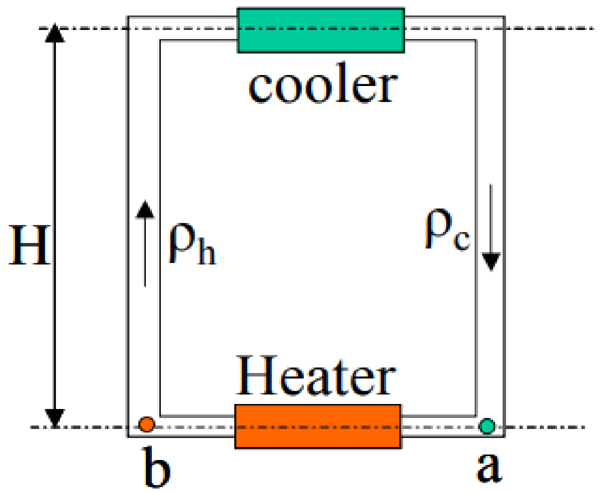
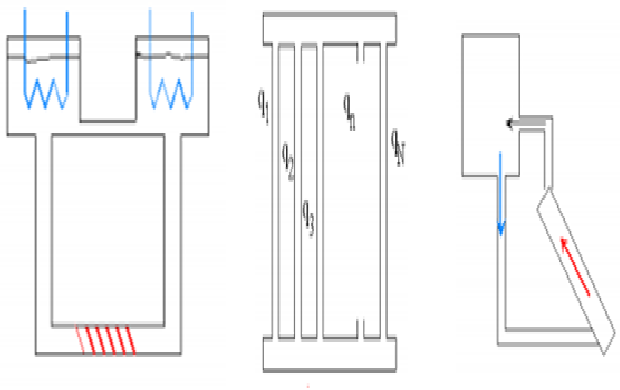


Fig 1. Single-phase Natural Circulation Loop (NCL).



(a) (b) (c)

(a) Geo-thermal system, (b) Nuclear Power plant, (c) Solar Heater.

Figure 2: Engineering applications of NCL.

II. LITERATURE REVIEW

Dynamic execution of a natural circulation loop (NCL) has been examined under advance, slope, exponential and sinusoidal excitations. The loop is furnished with two heat exchangers at its lower and upper end for the heating and cooling of the loop fluid. For the examination, transient one-dimensional preservation conditions have been developed for the loop fluid just as for the two fluid streams of hot and cold end heat exchangers.

The arrangement of a lot of differential conditions and one integro-differential condition has been gotten through a limited component technique (FEM).

For various excitations forced to the bay temperature of the hot fluid reactions have been read for the outlet temperature of the two fluid streams and the mass stream pace of the coupling fluid It has been seen that every one of these amounts experience some underlying homeless people before arriving at the relentless state.

Time required for the achievement of relentless state differs with the kind of excitation. A limited time delay is seen before the cold fluid stream temperature begins reacting to the excitation. Heat exchanger using nanofluid in counter flowdirection.

1. Idea of Using Nano Fluids:

The principle goal or thought of utilizing nanofluids is to achieve most noteworthy conceivable thermal properties at the littlest potential focuses. A nanofluid is a blend of water and suspended metallic nano particles.

2. Stream in Liquid-Gas Flows:

probably lit up fluid stream of water in an inclined plane and viewed the prompt contact heat move with change of stage and estimated heat move coefficients for stratified laminar stream down in an inclined plane.

III. RESEARCH METHODOLOGY

1. Preparation of Nano Fluid:

A large variety of combinations of nanostructures and heat transfer fluids can be used to synthesize stable nanofluids with improved thermal transport properties. Nanostructures made from metals, oxides, carbides and carbon nanotubes can be dispersed into HTFs such as water, ethylene glycol, hydrocarbons and fluoro carbons with or without the presence of stabilizing agents.

Another method of nanofluid synthesis is the laser ablation method which has been used to produce alumina nano fluids. Pure chemical synthesis is also an option which has been used by Patel to prepare gold and silver nanoparticle nano fluids.

Zhu also use a one-step pure chemical synthesis method to prepare nanofluids of Cu nanoparticles dispersed in ethylene glycol.

2. Instruments/Equipment Used:

These products are comprised of a number of analog and digital inputs that are monitored, and the results or conditions of these inputs is then stored on some type of local memory (e.g. SD Card, Hard Drive).

Though they can be deployed while connected to a host PC over an Ethernet or serial port a data logger is more typically deployed as standalone devices. Once the application is programmed into the unit, it is placed in location, the various input (and output) signals are connected and the logging application is started.

Sensors commonly connected include: Thermo couples, RTDs, Thermistors, strain gages, load cells, pressure sensors, and event counters such as turnstiles, liquid level and many more.

Fig 3. Constant temperature water supply bath.\

3. Reagents Table:

Table 1. Sources and M.pt/B.pt of chemicals.

S.no.	Chemicals	M.pt/B.pt
1	Sodium Hydroxide (HIMEDIA)	318
2	Ammonium Hydroxide (HIMEDIA)	37
3	Aluminium Trichloride (SIGMA)	192
4	Zinc Acetate (SIGMA)	237
5	Cupric Acetate (SIGMA)	115
6	Ethylene Glycol (SIGMA)	197
7	Propylene Glycol (SIGMA)	188
8	Hexylene Glycol (SIGMA)	197
9	Acetone (THOMAS BAKER)	56
10	Ethanol (SIGMA)	78

4. Synthesis of Cupric Oxide Nanoparticles:

The synthesis of copper oxide nanoparticles is done by accelerating copper salt in basic medium. The copper salt solution utilized is newly arranged 0.2 M Cu (CH3COO) 2.2H2O.

The salt solution is blended in with 1 ml frosty acidic corrosive and the resultant solution is heated for two hours on a magnetic stirrer at a steady temperature of 60°C. Icy acidic corrosive is utilized to anticipate the hydrolysis of the copper acetic acid derivation solution.

On lively stirring, the above solution pH is expanded quickly to 10.5 by including NaOH pellets where a dark precipitate of CuO is framed immediately. At a similar pH, temperature and stirring velocity, the solution is kept at a digestion time of 30 minutes. In general chemical reaction can be composed as;

$$Cu(CH_3COO)_2 2H_2O + 2NaOH \rightarrow CuO + 2CH_3COONa + 3H_2O$$

IV. EXPERIMENT PROCEDURE

Nanoparticles of ZnO, CuO and Al2O3 were orchestrated. These integrated nanoparticles were then portrayed by utilizing different procedures like X-ray diffraction (XRD), transmission electron microscopy (TEM), scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX). Nanofluids of various centralizations of these materials were then arranged in three diverse base fluids which were 10% watery arrangements of ethylene glycol, propylene glycol and hexylene glycol with the assistance ofultrasonicator.

Fig 4. NCL Setup.

1. Characterization of Nanoparticles:
1.1 Characterization of Zno Nanoparticles:
X-ray Diffraction: The XRD pattern of the synthesized ZnO nanoparticles is appeared. All diffraction peaks can be indexed as the hexagonal wurtzite structure of ZnO by comparison with data from JCPDS record no. 36-1451, no characteristic peaks of any other impurity were watched. The sharp peaks indicate that the item is all around crystallized.

Table 2. XRD data of ZnO nanoparticles.

2theta (deg)	hkl	Height (cps)	FWHM (deg)	Int.I (cps)	Size (nm)
31.8756	100	14627.12	0.2171	4398.47	39.739
34.5327	002	12133.22	0.1945	3133.64	44.675
36.3683	101	24145.82	0.2272	7308.68	38.437
47.6443	102	5557.78	0.2325	1767.21	39.012
56.689	110	8685.9	0.2262	2711.92	41.684
62.942	103	7762.97	0.2209	2396.08	44.045
66.4704	200	1176.15	0.2262	351.72	43.846
68.0337	112	6259.58	0.2336	1986.58	42.851
69.166	201	3010.01	0.2382	948.7	42.316

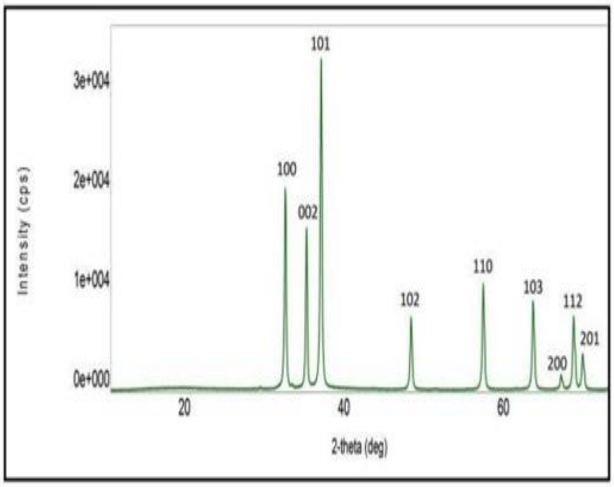


Fig 5. XRD patterns of ZnO nanoparticles.

2. Scanning Electronmicroscopy:
Scanning electron microscopy (SEM) is the primary apparatus utilized for the characterization of surface morphology of synthesized nano materials.

SEM image of the ZnO nanoparticles are portrayed in Fig.6 From SEM image only a little dispersion with part of agglomeration was watched.

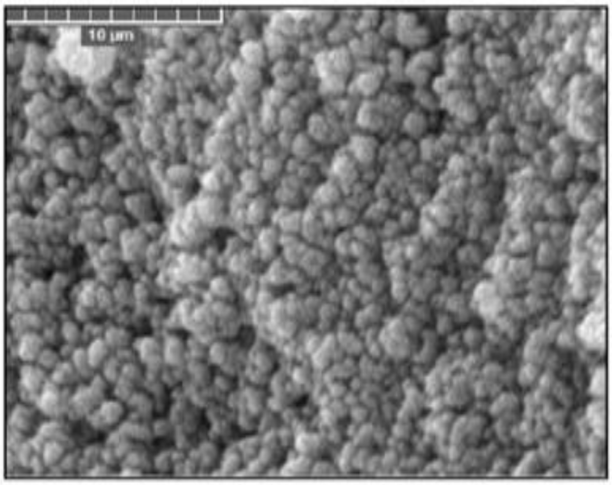


Fig 6. SEM image of ZnO nanoparticles.

3. Transmission Electron Microscopy:
Transmission electron microscopy (TEM) was utilized to examine the morphology and size of particles. Fig. 4.24 shows typical TEM micrographs of the synthesized Al2O3 nanoparticles at various magnifications.

The particle-size distribution histogram of Al2O3 nanoparticles appeared. indicates that the average diameter of nanoparticles tallied from the TEM image is about 10-14 nm.

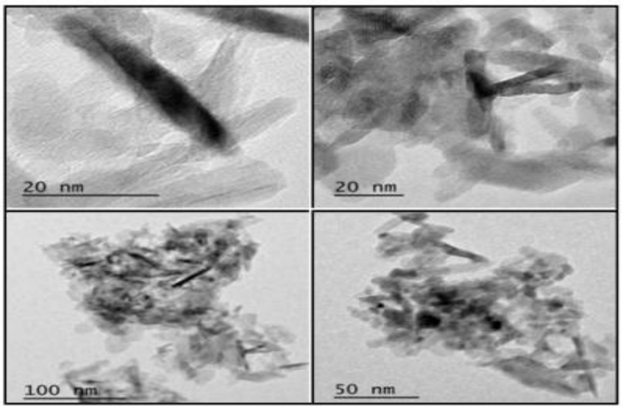


Fig 7. TEM micrograph of Al2O3 nanoparticles.

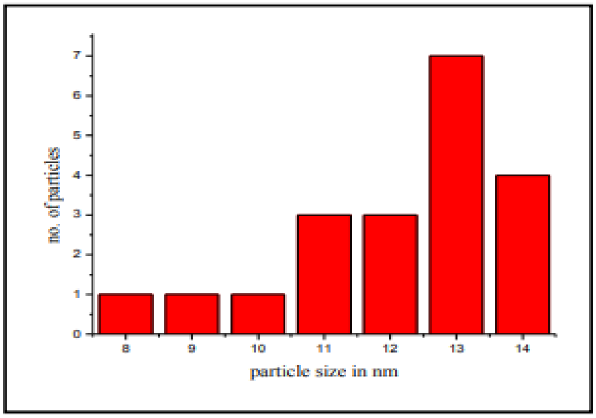


Fig 8. Particle size distribution histogram of Al2O3 nanoparticles.

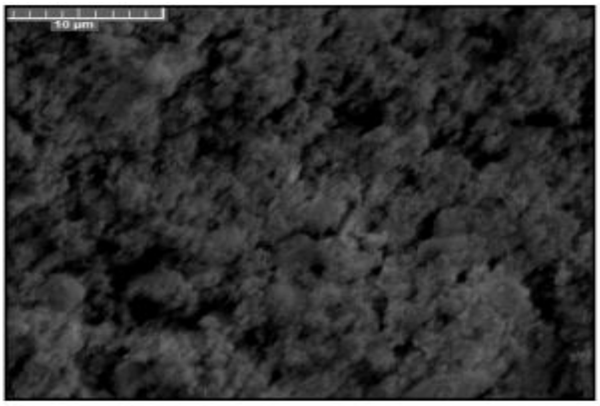


Fig 9. SEM images of Al2O3 nanoparticles.

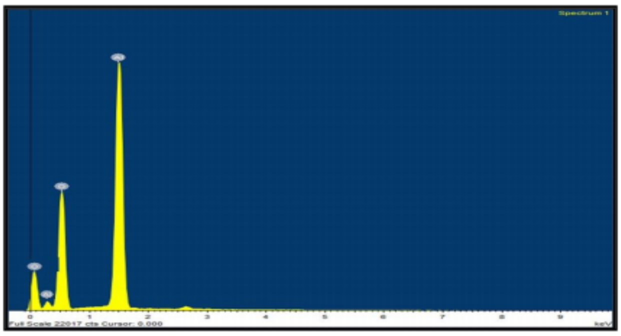


Fig 10. EDX spectrum of Al2O3 nanoparticles.

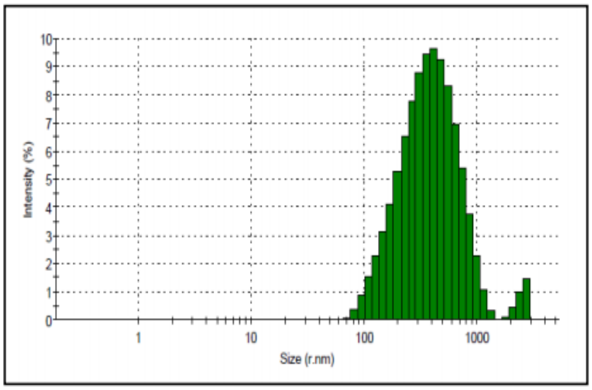


Fig 11. Size distributions by intensity of Al2O3 nanoparticles in 10% aqueous hexylene glycol.

V. EVALUATION OF ACOUSTIC AND THERMODYNAMIC PARAMETERS

1. Acoustic and Thermodynamic Parameters of Zno Nano fluids:

In the present investigation ultrasonic velocity (u), density (ρ) and viscosity (η) of various nanofluids of various concentrations in three distinctive base fluids which were 10% aqueous solutions of ethylene glycol, propylene glycol and hexylene glycol at three unique temperatures 303.15 K, 308.15 K and 308.15 K and at a recurrence of 5 MHz were measured. Various acoustic and thermodynamic parameters, for example, Gibb's free change (ΔG) and attenuation coefficient (α/f2) were evaluated by utilizing the measured values of ultrasonic velocity, density and viscosity.

Table 3. Ultrasonic velocity of various nanofluids of ZnO in 10% aqueous hexylene glycol at different temperatures.

Conc. (wt %)	Ultrasonic velocity ($u \times 10^{-3}$) (m s^{-1})		
	303.15 K	308.15 K	313.15 K
0	1.56636	1.57364	1.58091
0.02	1.56722	1.57455	1.58172
0.04	1.56781	1.57511	1.58236
0.06	1.56703	1.57434	1.58155
0.08	1.56654	1.57385	1.58108
0.10	1.56715	1.57443	1.58166

Table 4. Density of various nanofluids of ZnO in 10% aqueous hexylene glycol at different temperatures.

Conc. (wt %)	Density ($\rho \times 10^{-3}$) (kg m^{-3})		
	303.15 K	308.15 K	313.15 K
0	0.99504	0.99320	0.99116
0.02	0.99515	0.99328	0.99122
0.04	0.99535	0.99350	0.99144
0.06	0.99564	0.99380	0.99174
0.08	0.99588	0.99404	0.99200
0.10	0.99618	0.99433	0.99228

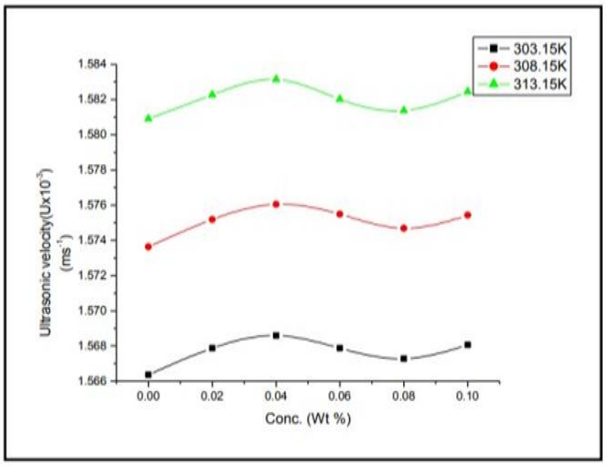


Fig 12. Plots of ultrasonic velocity of various nanofluids of ZnO in 10% aqueous hexylene glycol at different temperatures.

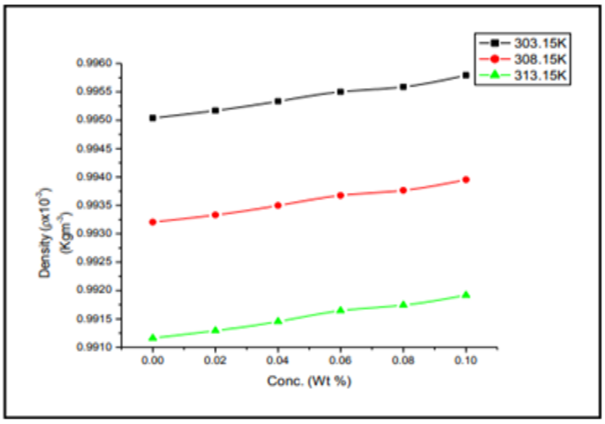


Fig 13: Plots of density of various nanofluids of ZnO in 10% aqueous hexylene glycol at different temperatures.

Table 5. Ultrasonic velocity of various nanofluids of Al2O3 in 10% aqueous hexylene glycol at different temperatures.

Conc. (wt %)	Ultrasonic velocity ($u \times 10^{-3}$) (m s^{-1})		
	303.15 K	308.15 K	313.15 K
0	1.56636	1.57364	1.58091
0.02	1.56788	1.57518	1.58227
0.04	1.56859	1.57605	1.58315
0.06	1.56788	1.57549	1.58202
0.08	1.56727	1.57469	1.58137
0.10	1.56806	1.57543	1.58245

Table 6. Density of various nanofluids of Al2O3 in 10% aqueous hexylene glycol at different temperatures.

Conc. (wt %)	Density ($\rho \times 10^{-3}$) (kg m^{-3})		
	303.15 K	308.15 K	313.15 K
0	0.99504	0.99320	0.99116
0.02	0.99517	0.99333	0.99129
0.04	0.99533	0.99350	0.99145
0.06	0.99550	0.99367	0.99164
0.08	0.99559	0.99376	0.99174
0.10	0.99579	0.99395	0.99192

Table 7. Viscosity of various nanofluids of Al2O3 in 10% aqueous hexylene glycol at different temperatures.

Conc. (wt %)	Viscosity ($\eta \times 10^{3}$)(kg m^{-1} s^{-1})		
	303.15 K	308.15 K	313.15 K
0	1.09244	0.97825	0.86290
0.02	1.11285	0.99325	0.88080
0.04	1.11809	0.99784	0.89343
0.06	1.11202	0.99209	0.88873
0.08	1.10868	0.98917	0.88501
0.10	1.11228	0.99903	0.89506

Table 8. Relaxation time of various nanofluids of Al2O3 in 10% aqueous hexylene glycol at different temperatures.

Conc. (wt %)	Relaxation time ($\tau \times 10^{13}$) (s)		
	303.15 K	308.15 K	313.15 K
0	5.96637	5.30322	4.64453
0.02	6.06531	5.37331	4.73207
0.04	6.08735	5.39130	4.79383
0.06	6.05876	5.36308	4.77451
0.08	6.04473	5.35225	4.75792
0.10	6.05702	5.39950	4.80458

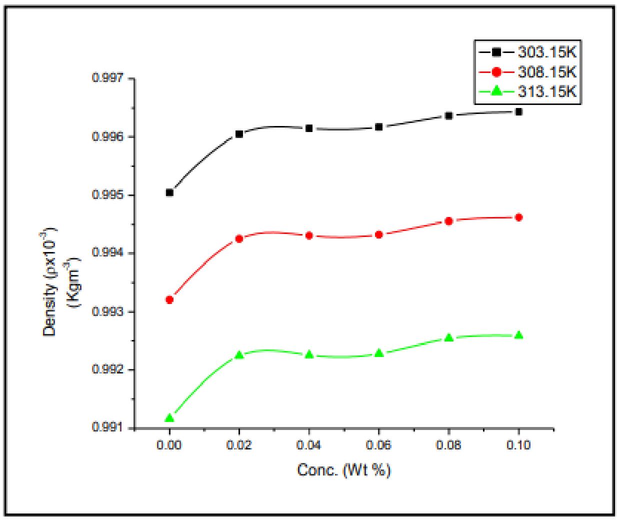


Fig 14. Plots of density of various nanofluids of Al2O3 in 10% aqueous hexylene glycol at different temperatures.

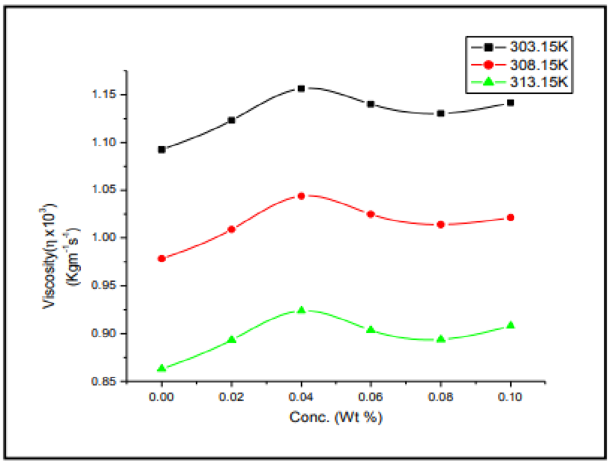


Fig 15. Plots of viscosity of various nanofluids of Al2O3 in 10% aqueous hexylene glycol at different temperatures.

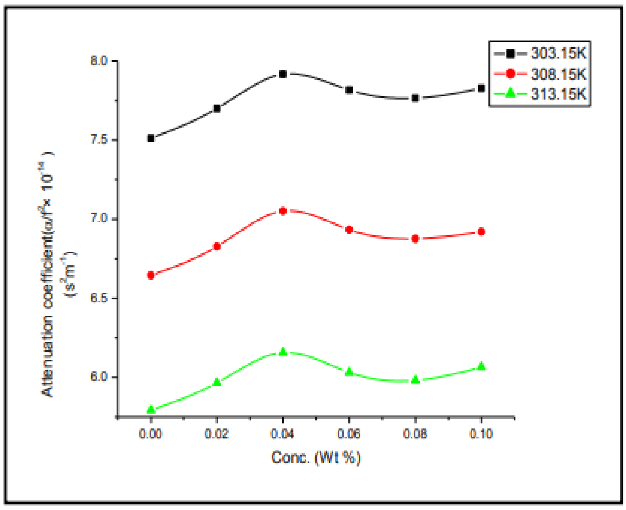


Fig 16. Plots of attenuation coefficient of various nanofluids of Al2O3 in 10% aqueous hexylene glycol at different temperatures.

The expansion in ultrasonic velocity and viscosity at lower convergence of Al2O3 nanoparticles is because of dipole cooperations of Al2O3 nanoparticles with glycol and water molecules (Al2O3-glycol-H2O) because of these associations generally speaking compressibility of the medium abatements and consequently ultrasonic velocity and viscosity increments.

Be that as it may, over a specific fixation (0.04 wt%) of Al2O3 nanoparticles their associations with glycol (Al2O3-glycol) and water molecules (Al2O3-H2O) builds which thus start diminishing the hydrogen holding among glycol and water molecules (glycol-H2O) therefore in general compressibility of the medium increments and henceforth ultrasonic velocity and viscosity diminishes. At some higher fixation (0.08 wt%) of Al2O3 nanoparticles they start amassing due to bury particle communications (Al2O3-Al2O3) and subsequently their associations with glycol (Al2O3-glycol) and water molecules (Al2O3-H2O) diminishing which thus expands the hydrogen holding among glycol and water molecules (glycol-H2O) and consequently a little increment happens in the estimations of ultrasonic velocity and viscosity.

In the event of fluid hexylene glycol and watery ethylene glycol thickness continues expanding with increment in centralization of Al2O3 nanoparticles yet in the event of watery propylene glycol there happens an expansion in thickness up to some fixation and after that it begins diminishing lastly an increment happens.

VI. CONCLUSION

Investigation the following conclusions would be expected: Firstly, the stabilization of loop fluid is achieved with the introduction of nano particles.

The fluctuations in the velocity vs time curve would be decrease order and almost become linear with time. Also the enhancement of flow rate in the loop may be record with the increase of temperature of heat source and also with the increase of volume fraction of Al2O3 in nano fluid.

Expected regular pattern of drop in efficiency would be notice when temperature of HEHE changes from 70 to 900C. The optimal conditions for heat transfer through the loop would be at 850C and 0.75% of concentration Nano fluid, for which the efficiency may be 65-70 %.

In the present work ZnO and Al2O3 nanoparticles have been blended by various methods. These orchestrated nanoparticles were then portrayed by utilizing different systems like X-ray diffraction (XRD), transmission electron microscopy (TEM), scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX).

Nanofluids of different fixations have been set up from these orchestrated nanoparticles in three diverse base fluids, which were 10% watery arrangements of ethylene glycol, propylene glycol and hexylene glycol with the assistance of ultrasonicate. Thickness, viscosity and ultrasonic velocity at 5 MHz were resolved for these nanofluids at three distinct temperatures.

This expansion in viscosity prompts a higher shear worry between the fluid and the encompassing surface. Additionally, the nanoparticles facilitated by the fluid are well on the way to store on the internal surface of the pipe when utilized in raised temperature applications, causing what is known as the fouling effect.

The stored layer or foul would act also as inward pipe covering with nanoparticles (i.e., nanocoating) since the foul is framed from nanoparticles that were facilitated by the transporter fluid itself.These orchestrated nanoparticles were then portrayed by utilizing different systems like X-ray diffraction (XRD), transmission electron microscopy (TEM), scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX).

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