

# Experimental Study of the Comparison of Thermal Conductivity, Absorption Ratio & Viscosity of Al<sub>2</sub>O<sub>3</sub>-Alpha Nanofluid with Lubricating Oil (320-SZ) & (160-MPZ)

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**Abstract** – In recent years, Heat Transfer Enhancement becomes revolutionized with the discovery of Nanofluids. Heat transfer Characteristics enhances Thermal Efficiency up to higher extent. This research Investigates how Alumina (ALPHA) Nanoparticles enhances Thermal Efficiency with the increasing size in their volume concentration, stability and phase verification. This research study explores that with the increasing size of Volume concentration usually ranges from (0.1% to 5%) Alumina (ALPHA) Nanofluid 20nm size with base fluid Lubricating oil (320-SZ) & (160-MPZ) shows better Thermal Conductivity results as compared to the Thermal conductivity of base fluid i.e Lubricating oil (320-SZ) & (160-MPZ). This research methodology depicts various techniques to enhance Thermal conductivity; Stability and Heat transfer Property of Nanofluids. This Experiment Research works shows following results that with the Increasing size of volume concentration usually ranges from 0.1% to 5% Alumina (ALPHA) Nanofluid with base fluid i.e lubricating oil (160-MPZ) & (320-SZ) enhances better Thermal Conductivity as compared to Thermal Conductivity of Lubricating oil (160-MPZ) & (320-SZ). In addition to this research Effect on Absorption ratio & Viscosity of Alumina (Gamma) Nanofluids with base fluid lubricating oil (320-SZ) & (160-MPZ) have been also studied. This research also concludes different Surfactants and their effect on Alumina (ALPHA) Nanofluids with base fluid (160-MPZ) & (320-SZ).

**Keywords:** Nanoparticles, Thermal Conductivity, Lubricating oil (320-SZ) & (160-MPZ), Surfactants, Thermal Properties.

## ABBREVIATIONS

<b>Vol:</b>	Volume
<b>TEM:</b>	Transmission Electron Microscope
<b>SEM:</b>	Scanning Electron Microscope
<b>CU:</b>	Copper
<b>AG:</b>	Silver
<b>XRD:</b>	X-Ray Diffraction
<b>CFD:</b>	Computational Fluid Dynamics
<b>UVS:</b>	Ultra visible spectroscopy
<b>μ:</b>	Viscosity

<b>Al<sub>2</sub>O<sub>3</sub>:</b>	Aluminum Oxide
<b>TiO<sub>2</sub>:</b>	Titanium Oxide
<b>K<sub>oil</sub>:</b>	Thermal Conductivity of Base fluid
<b>K<sub>nf</sub>:</b>	Thermal Conductivity of Nanofluid
<b>α:</b>	Alpha
<b>m:</b>	Mass flow rate
<b>L<sub>oil</sub>:</b>	Lubricating oil (160-MPZ) & (320-SZ)

## I. INTRODUCTION

With the discovery of nanofluids Enhancement in Thermal conductivity occurs to a higher level. This is because due to the heat transfer properties of nanofluids. They exhibit extreme enhancement in Thermal conductivity as compared to their conventional fluid. With their discovery of nanoparticles in 1995 by Stephen. S. choi the whole Thermal Enhancement process changes. The reason for this is the size, property and shape of the nanoparticles. Nanoparticles size is of between 1 to 100nm; due to their extremely small size 1 to 100nm they can easily mixed with any base fluid like water, lubricating oil, kersone, Refrigerants. Nanoparticles are such a great fluid that the can easily seen with naked eyes. Nanofluids are engineered colloidal suspension of nanoparticles in a base fluid. Experiment research shows that a nanofluid shows enhancement in heat transfer processes upto 40% as compared to the other fluids or Conventional Fluids. This extreme heat transfer enhancement makes nanofluids great superior fluids as compared to microfluids or other Conventional Fluid. They are made up of metals, oxides, carbides etc. The unique property of Nanofluid is that they can easily visible with naked eyes. They exhibit excellent Thermal properties as compared to their base fluids. It's hard to imagine how small the size of nanometer is one nanometer is a billionth of a meter, or 10<sup>-9</sup> of a meter. This revolution of heat Enhancement process with the discovery of Nanofluids makes its way for different process like in Boilers, Thermal plants, Refrigeration plants all these processes exhibit higher Thermal Efficiency due to Nanofluids. In refrigeration plants when used Nanorefrigerant (Nanoparticles +Refrigerant) efficiency or COP increases due to Nanofluids Thermal properties. The naoparticle used in nanofluids are made up of metals, oxides, carbidesit mixes with base fluid like lubricating oil, Refrigerant and mainly water. Certain base fluids like water,

different lubricating oil i.e (320-SZ), (160-MPZ), Enhanced their Thermal properties when Nanofluids are used. Nanofluids are used in very small volume concentration starts from (0.01 to 5%). These small concentrations make their Thermal properties to a higher level due to Nanofluid or Nanoparticles.

## II. LITERATURE REVIEW

**M. Saleem Ahmed [1] [2019]:** In this study, paper Thermal Conductivity enhancement has been studied. Various Technique of Stability, preparation of Nanofluids has been discussed. Thermo physical properties and their enhancement with Nanofluids have been explored.

**Abdul kaggwa & James K.Carson [2]:** A literature paper has been developed for the development and future scope of Nanofluid technology in Thermal Enhancement by increasing heat transfer rate.

**Hamzeh T. Alkassabeh, Et. Al. [3] [2020]:** Published paper on Casson Nanofluids under the impact of Magnetic field.

**Z. Alhajal Et. Al. [4] [2020]:** Presented paper on comparative study on best configuration for heat enhancement using nanofluid. In this present study, three different configurations (porous block, porous straight channel and porous wavy channels) setups were investigated numerically using four different types of nanofluids mainly, 0.5% vol Al<sub>2</sub>O<sub>3</sub>/Water, 0.5% vol TiO<sub>2</sub>/Water, 0.5% vol Al<sub>2</sub>O<sub>3</sub>/Ethylene Glycol and 0.5% vol TiO<sub>2</sub>/Ethylene Glycol.

**T.Elnaqeeb Et. Al. [5] [2020]:** Discuss Unsteady natural convective flows of nanofluids in a vertical channel with circular cross-section have been investigated using the integral method transforms.

**Vijaya Lakshmi Et.al (6) [2020]:** The present research explores the features of thermal and solutal transport of a 3D micropolar liquid stream on an elongated convectively heated inclined sheet taking Soret effect. Mathematical modelling is designed with the aid of suitable scaling analysis on the governing PDEs conceiving the small magnetic Reynolds number.

**P.Sridevi ET. AL (7) [2020]:** In the current study, we have scrutinized the sway of non-linear thermal radiation and Biot number on boundary layer flow along a continuously moving thin needle filled with carbon based nanotubes by considering water as regular fluid. The main system of partial differential equations is first reduced to the system of ordinary non-linear differential equations with the help of similarity conversion technique.

**Sakshi Jain Et.al [8] [2020]:** In this research work a new Nanofluid Al/Al<sub>2</sub>O<sub>3</sub> water Hybrid nanofluid is studied. Experimental result shows that employing Hybrid nanofluid increase in heat transfer rate upto 15%. Furthermore average Nusselt number and heat transfer coefficient also increases.

**Roy Jean Essa (9) [2021]:** This research paper demonstrates that size of an Automobile radiator is reduced by the enhancement of Alumina nanoparticles.

**Anirban Das Et.al (10) [2021]:** These Research scholar conduct research on Thermophysical properties and its effect on the Enhancement of Thermophysical properties. Results shows 30 % enhancement in heat transfer with nanofluids as compared to base fluid.

**S.Rana Et.Al (11) [2021]:** A numerical approach has been established to compare the Thermal performance of various nanofluids in a double backward facing channel.

**R. Rajput & Harish Sahu (12) [2022]:** Analysis through their research effect of different Nanofluid flow in Microchannel heat sink A CFD analysis is done and it shows TiO<sub>2</sub> better Thermal heat transfer coefficient as compared to other Nanofluids.

**Y. Sawant, Et. al (13) [2021]:** This study works present Nanofluids application in present and future scope. Different possibilities have been explored in this research paper. It shows Heat transfer enhancement of Nanofluids and their application in present and for future purpose.

**S. Mukherjee Et. al (14) [2022]:** This research paper collects the literature review on Hybrid nanofluids and their application. It depicts literature review on Hybrid nanofluids and their future applications. The concept of Hybrid Nanofluids shows an exceptional increase in Thermophysical properties of Nanofluids. Furthermore result shows that increase in Thermal conductivity enhances from 15 to 20%, density increase upto 0.75% and specific heat capacity changes from 1 to 45% .

**M. Hedeishi Et. Al. (15) [2023]:** In this paper effect of Nanofluids and ultrasonic vibrations in a double pipe heat exchanger are experimentally investigated. Result shows by using ultra sonic in nanofluids can enhance thermal efficiency upto 18% and 43%.

**Archie Thakur Et. al (16) [2023]:** Tri-hybrid nanofluids are formed by involving three different types of nanoparticles in the base fluid. In recent years, studies have been done to properly understand the factors that affect the heat transfer properties of these tri-hybrid nanofluids under various circumstances. The purpose of this study is to execute a study

on an advanced tri-hybrid nanofluid model for heat transfer. No previous analysis has been executed for the flow of tri-hybrid nanofluid  $\text{TiO}_2\text{-Al}_2\text{O}_3\text{-SiO}_2/\text{H}_2\text{O}$  past a variably thickened stretching sheet with the inclusion of Newtonian heating, magnetic field, mixed convection, thermal radiation, and viscous dissipation. This investigation confronts the heat transfer characteristics of boundary layer mixed convective flow of  $\text{TiO}_2\text{-Al}_2\text{O}_3\text{-SiO}_2/\text{H}_2\text{O}$  tri-hybrid nanofluid on a variably thickened stretching sheet along with the inclusion of thermal radiation, viscous dissipation, and Newtonian heating. The ruling boundary layer equations are manipulated into an arrangement of ODEs using appropriate similarity transformations which are worked out with the bvp4c program in MATLAB for solutions.

**Anwar Ali ET. al (17) [2023]:** This paper introduces the application of fractional derivative to the heat transformation of a nanofluid along with ramped wall Temperature.

**C. Manoj Kumar ET. al (18) [2024]:** This study presents a comprehensive numerical and statistical analysis of the flow, heat/mass transfer management of Newtonian and non-Newtonian nanofluid over a bidirectional Darcy-Forcheimer stretching sheet. The external effects of MHD, Joule heating, thermal radiation, heat generation/absorption, Brownian motion, thermal diffusion and chemical reaction are taken into account. It is presumed that the thermal conductivity of fluid varies linearly with temperature. The non-linear coupled P.D.Es are converted into nonlinear coupled O.D.Es using similarity transformation. These equations are solved using MATLAB by implementing four-stage Lobatto IIIa formula and the outcomes of numerous flow parameters are presented graphically. In addition to numerical investigations, a comprehensive statistical analysis is performed using R-software to evaluate the sensitivity of key input parameters towards variable thermal conductivity.

**Janhanvi K.R & Ganesh Shridhar (19) [2024]:** Both research scholars presented a paper on Mathematical modelling, Application and Review of Nanofluid properties. Different New approaches have been adopted by them.

**A.samanta Et. al (20) [2024]:** Presented paper on Mathematical modelling on Nusselt number studied Copper Nnanofluid Lubricating oil .

**Farah M.Abdul Razzaq & Adnan S.Jabar (21) [2024]:** Presented a research paper on the Evolution of Alpha nanoparticles, their evolution, characterization etc. Their research shows they Prepared  $\alpha$ - Alumina Nanoparticles by Sol Gel Method.

**Amlal Et. al (21) [2025]:** The significance of nanofluids is increasingly acknowledged due to their application across

various fields to enhance the properties of mixtures. A significant challenge lies in accurately calculating their thermo physical properties, as no theoretical formula currently exists that can estimate these with precision conductivity and dynamic viscosity.

### III. PREPARATION OF NANOFLUID

Preparation of Nanofluids is the most important step in this field. There are two types of methods 1) Single step method 2) Double step method.

Upon the synthesis, characterization, Phase parameters these two methods are taken into accounts..

#### Single step method:

It is the most simplest method in the field of Nanofluid. It makes the formation and dispersion of nanoparticles in a simultaneous way. Single step Method makes synthesis of Nanoparticles and Nanofluid in one step In this method creation and dispersion of Nanoparticles in base fluid like water, oil are done in simultaneous way. In this Method Agglomeration is reduced, stability is increased. Another major con of this method is their high cost.

#### Two step method:

This method is commonly used worldwide as it is the most famous method in nanofluids. The simple principle of this method is first make nanoparticles in dry powder form using techniques like CVD (chemical; vapour deposition), thermal spray and spray pyrolysis, Sonication and settling. Most process using nanofluids are produced by this method. It is also used in high scale nanoscale production. It struggles in agglomeration and it needed surfactants for the stabilizing of Nanofluids. It is better use for Bulk production of Nanofluids etc for the commercial aspect this method is suitable as it produces large quality of nanofluids. Experiment research shows that certain nanofluids like Ag, Cu are prepared by one step and then with two step method techniques. It is observed stability of one step method is better than two step method , other Thermo physical properties when compared studies shows by one step method Thermal conductivity increased by 18% while that of two step it is increased by 31%. Second observation reveals that one step method is more stable than two step method. Nanoparticles with oxide are prepared by two step method while metals nanoparticles are prepared by one step method. Following techniques are used in this method for the efficiency of nanofluids:

- a) High shear
- b) Ultrasonication
- c) Microemulsion

These preparation method is extreme important for making a Nanofluid. These steps whether one step or two step makes an important role in making an Nanofluid , their different efficiency, capabilities an superior heat transfer. These methods are based on Nanofluid structure, shape and base fluid. For example most nanofluid with base fluid water are prepared by one step method while those of lubricating oil like 160-SZ, 160-POE, 160-SO, 160-SZ, 160- MPZ, 320-SZ and kerosene oil are prepared by two step method.

Two steps is the edge over one step method over his suspension, heat capacities and absorption properties. The Two step method is the best method for nanofluid when base fluid is lubricating oil. This method Enhances Thermal Properties. In this Research Methodology Two step Method is used.

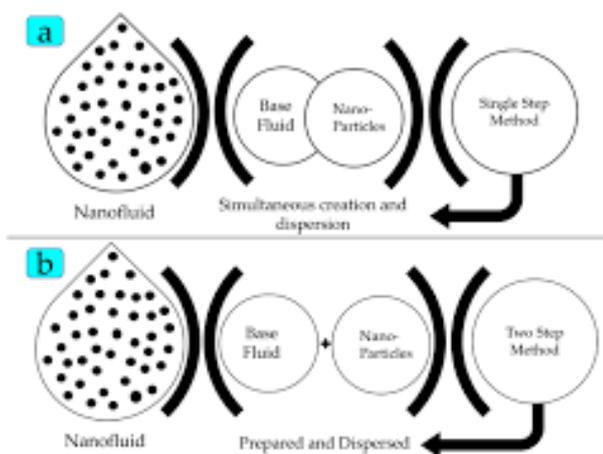


Figure 1: Shows Single Step and Double Step Nanofluid Method

Figure a shows layout of single step and double step method. Single step shows dispersion and creation in a simultaneous way. Fig b shows Preparation and dispersion in different way in two step method by this layout. Some advantages of Nanofluid are 1) Best utilized for large scale nanofluid production 2) It is mostly cost effective and in budget limit 3) Best application is it is used for oxide nanoparticles 4) Base fluids used is lubricating oil, water etc 5) Provide greater flexibility 6) Stability enhanced by the use of Surfactants. 7) Nanoparticles easily aggregate due to high surface area and property.

**IV. METHOD OF STABILITY FOR NANOFUID**

Methods used in the stability of nanofluids are

- 1) Analysis by zeta potential
- 2) Using surfactants as a stabilizer
- 3) Ultraviolet-Visible Spectroscopy

**1) Zeta potential:**

Research shows when zeta potential is higher it indicates higher stability of nanofluid mixtures. When zeta potential is low colloidal suspension stability is lowered. Further it shows from the experimental data when zeta potential values are in the range of -41 to -50mv the stability is extreme high. On the other side’s when zeta potential value is in -11 mv to -20 mv the stability is lowered. Further research shows values for the stability of nanofluid depends on zeta potential values.

Rapid coagulation occurs when zeta potential falls +\_ 5mv.

Incident stability occurs wen zeta potential is in 10 to 30 mv.

Moderate stability occurs when value of zeta potential is 30 to 40 mv.

Good stability of nanofluid occur when zeta potential is in the range of 40 to 60 mv

Excellent stability of nanofluid when zeta potential falls to +- 61mv.

**2) Surfactants:**

To prevent nanoparticles agglomeration and settling different surfactants are used for the stablizing of nanoparticles mixture. It works on the principle that creates layer around the nanoparticles that helps to improve dispersion in fluid (base fluid). Different types of various surfactants are used in various nanofluids for eg Al<sub>2</sub>O<sub>3</sub> water, Cuo Water, Al<sub>2</sub>O<sub>3</sub> lubricating oil for the proper dispersion and stability. Surfactants are the molecules like amphiphile molecules that consist of hydropholic and hydrophobic ends. Its principle is to break the intermolecular bonds that further leads to the decrease in surface tension and μ. These surfactants wen added to the nanofluid the chances of agglomeration and coagulation of nanoparticles decreases gradually.

Surfactants can be classified as

- 1) Anionic surfactants
- 2) Ammonium and amines
- 3) Sodium dodecyl sulphates

**3) Ultraviolet-Visible Spectroscopy:**

It increases the stability of nanofluid by calculating the absorbance. It is de modern method. It is based on principle that absorbance is directly propotional to the fluid tested via its concentration. It is based on beer lambert law. Single-step method and two-step method is used for the preparation of Nano fluids. Stable suspension of nanoparticles in conventional heat transfer fluids are produced by these two

methods. Out of these two methods two-step method is commonly used for the preparation of nanofluids. The two-step method first makes nanoparticles in dry powder form using nanoparticle processing technique such as Chemical vapour deposition (CVD), chemical precipitation, microemulsion, thermal spray and spray pyrolysis. The next step is the dispersion of nanosized powder form into the base fluid. For nanofluids prepared by the two step method dispersion techniques such as high shear and ultrasonication can be used to create various particle-fluid combinations. Most nanofluids containing oxide nanoparticles are produced by two step method. Wang et al.[5], Zhu et al. [6] explained that two step method is mostly used for the oxide nanoparticles. Preparation of nanofluid in one step is carried by one step method. The single step method simultaneously makes and disperses nanoparticles directly into base fluids. In these methods synthesis of nanoparticles as well as the nanofluid is done in a single step. It is a process combining the preparation of nanoparticles with the synthesis of nanofluids for which the nanoparticles are directly prepared by physical vapour deposition (PVD) technique or liquid chemical method. Nanofluid Stability is increased & agglomeration of these particles are extend to negligible extend due to missing of Process like, Transportation, storage & drying. The cons of this method are that only low vapour pressure fluids are compatible with this process. This method is much more costly as compared to the double step method. In this research work  $Al_2O_3$ /lubricating oil nanofluid is prepared by two step method.

Table 1: Properties of Nanoparticle

Particle	Aluminium Oxide nanopowder ( $Al_2O_3$ )(ALPHA)
Avg. particle diameter	20 nm (Alpha)
Density	3.9 to 4.0 g/cm <sup>3</sup>
Bulk Density	0.3 g/cm <sup>3</sup>
Purity	99.99%
Melting Point	2050
Boiling Point	2990
Colour	Ivory/White
Crystal Structure	Rhombohedral
Ph value	7-9
Surface Area	Low Surface Area
Applications	Wear Resistant part, Cutting tool

Table 2: Properties of Base fluid i.e. lubricating oil (160-MPZ)

OIL	160-MPZ
Viscosity	31-33cst
Density	0.97 g/ml
Pour Point	-45 <sup>0</sup> C

Flash Point	217 <sup>0</sup> C
Dielectric strength	47kv
Colour	0.5
Acid value	0.15mgKOH/gm

Table 3: Properties of IIND Base fluid i.e Lubricating oil (320-SZ)

OIL	320-SZ
Viscosity	58-70cst
Density	0.957 g/ml
Pour Point	-43 <sup>0</sup> C
Flash Point	263 <sup>0</sup> C
Dielectric strength	49.4kv
Colour	-
Acid value	0.05mgKOH/gm

### V. THERMAL CONDUCTIVITY MEASUREMENT

KD2 Pro method is the best and most effective method for finding the Thermal Conductivity of Nanofluids. Almost all nanofluids check their Thermal conductivity measurement by this technique. This method is most accurate and fast method for the measurement of Thermal conductivity of nanofluids. KD2 Pro is a hand held device used to measure thermal properties. It consists of handheld controller and two sensors one is single and other is dual that can be inserted into the medium.

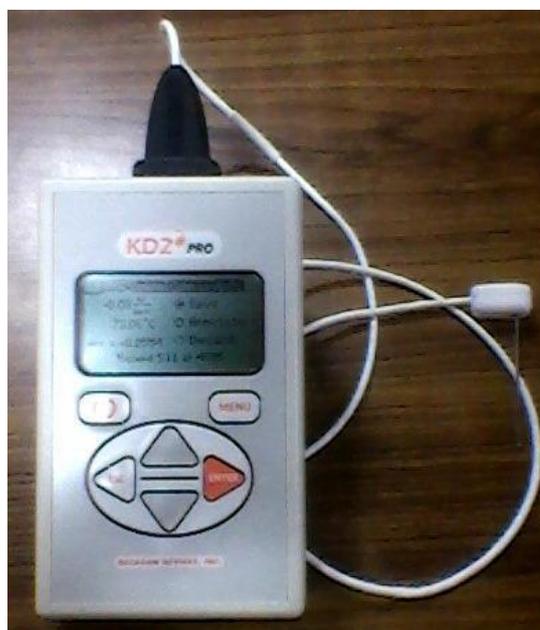


Figure 2: KD2 Pro Method

The Thermal conductivity and resistivity is measured by single needle sensors while the dual needle sensors determines Specific heat, Thermal diffusivity etc. FeiDuan [7] and Murshed et al [8] explained that the KD2 Pro method is best and easy methods for measuring Thermal conductivity of

nanofluids and it is designed in such a way for easy to use and maximum functionality. KD2 Pro device consists of a handheld microcontroller and sensor needles. The KD2's sensors needle contains both a heating element and a thermistor at the end of the reading, the controller computes the thermal conductivity using the change in temperature.

(T)-time data from

$$K = \frac{q (\ln t_2 - \ln t_1)}{4\pi (\Delta T_2 - \Delta T_1)}$$

Where q is constant heat rate applied to an infinitely long and small line source in  $W/m^2$ . In this present work Thermal conductivity of  $Al_2O_3$  Nanofluid with base fluid (320-SZ) & (160-MPZ) is found by this KD2 Pro method.

### VI. STABILITY OF ALUMINA (ALPHA) NANOFLUID

The preparation and stability of these lubricant and nanoparticle mixture are very important. The size of Alumina nanoparticles is about 20 nm as mentioned by the company. Nanofluids are not simply liquid solid mixtures. Nanofluids are prepared by using single step or two step method. In the present study two step methods is used. The Alumina (Alpha) nanoparticles corresponding to volume fraction 0.1%, 0.25%, 0.5%, 1%, 2% and 3% is weigh in exact amount with the help of digital weighing balance machine. In this way six samples of the Alumina (Alpha) Nanofluids in lubricating oil (160-MPZ) & (320-SZ) were prepared with different concentration of alumina alpha and alumina gamma (0.1%, 0.25%, 0.5%, 1%, 2% and 3%) by volume in base fluid i.e. lubricating oil (160-MPZ) & (320-SZ) Then, take 60 ml lubricating oil in a beaker, and pour the calculated amount of alumina Alpha nanoparticles in the beaker very gently, avoiding the sticking of nanoparticles on the beaker wall. Then place this beaker in ultrasonicator for at least 2-3 hours for proper mixing. Standard density of Alumina nanoparticles were taken to be 3.72gm/cc. Table 2 shows the required weight of alumina powder for the preparation of 60 ml nanofluids of different concentration by volume.

Table 2: Percentage of Alumina per weight as per volume concentration

% of Alumina (ALPHA) by volume in base fluid	Required weight of Alumina in gm.
0.1%	0.23 gm
0.25%	0.58gm
0.50%	1.164gm
1 %	2.328gm
2%	4.656gm
3%	6.984 gm

### VII. SONICATION

Nanoparticles cannot easily disperse into the liquid i.e. their base fluids like water, ethylene glycol, oil and lubricating oil. Nanofluids with the same nanoparticles and base fluids can behave differently due to different Nanofluids preparation methods. This will lead to agglomerate sizes in Nanofluids that can impact the thermal conductivity of Nanofluids and lead to a different heat transfer performance. So, a common way to break up agglomerates and promotes dispersion of nanoparticles into their base fluids Sonication is required. In this research work Alumina Alpha Nanofluids have gone to sonication for 3 hrs for the proper settling of Alumina nanoparticles into the base fluid.



Figure 3: Ultrasonic Vibrator

Sonication is done for the dispersion of nanoparticles into their base fluids with the help of Ultra Sonication, different nanoparticles have taking different time for the dispersion of nanofluids depending upon their chemical properties, some nanofluids doesnt dispersed easily in that cases some surfactants have been added for the dispersion of nanofluids. Sonication is commonly used in nanotechnology for evenly dispersing nanoparticles in their base fluids.

### VIII. NANOFLUID PHASE, STABILITY

Phase of Alumina (ALPHA) NANOFLUID IS Checked by XRD Technique. It indicates the phase identification by using XRD Machine. Different graphs have been made for different Nanofluids. Alumina (ALPHA) Nanofluid graph have been identified through machine that shows peak, curve and their reflection. Peas show different angles to which Phase of Nanofluid has been rectified. Peak of Alumina (Alpha) Nanofluid has been verified through XRD Machines. It catches certain coordinates and angle value through material of Nanofluid occurs. Similarly XRD (X-ray diffraction) is a

technique used to characterize the crystalline structure of nanoparticles before they are used to create nanofluids. It confirms the phase purity and determines the crystallite size of the nanoparticles dispersed in the base fluid to study their properties. Analyzing the dried solid component of the nanofluid with XRD reveals the diffraction pattern of the constituent nanoparticles, like metal oxides. XRD is used with nanofluids.

**Nanoparticle characterization:**

Before being added to a base fluid, the nanoparticles are analyzed using XRD to confirm their crystal structure and phase purity.

**Crystallite size determination:**

XRD data can be used to calculate the average size of the nanocrystals.

**Phase confirmation:**

In hybrid nanofluids, which contain multiple types of nanoparticles, XRD confirms the presence of each crystalline component by showing the combined diffraction peaks from each phase.

Different Phase analysis is done by XRD technique it analysis the phase of different Nanofluids.

Nanofluids like Al<sub>2</sub>O<sub>3</sub>, Copper Nanofluids, Gold Nanofluids phase identification is done by XRD Technique.

**IX. VISCOSITY MEASUREMENT**

For measuring viscosity of Nanofluids ultraviscos meter is used. It measures viscosity of different Nanofluids at different volume concentration. Viscosity depends on various parameters like 1) Particle size, 2) Particle shape, 3) stabilization of Nanofluids mixtures, 4) Most important key factor in measuring viscosity is the Temperature, 5) PH value is another factor consider in measuring viscosity.

**X. RESULTS AND DISCUSSION**

The Thermal conductivity of Alumina (Alpha) Nanofluids with base fluid lubricating oil (320-SZ) & (160-MPZ) has been compared with different volume concentration 0.1, 0.25, 0.5, 1% , 2% and 3% to shows that which Alumina (Alpha) nanofluid has better Thermal conductivity with different base fluid lubricating oil (320-SZ) &(160-MPZ).. The Graph I shows the thermal conductivity of the different volume concentration of Alumina (Alpha) Nanofluids mixed with the base fluid (320- SZ) i.e. Lubricating oil.

Graph 1 shows Thermal conductivity of Lubricating oil (320-SZ) in volume concentration starts from 0.01 to 5% with respect to Temperature.

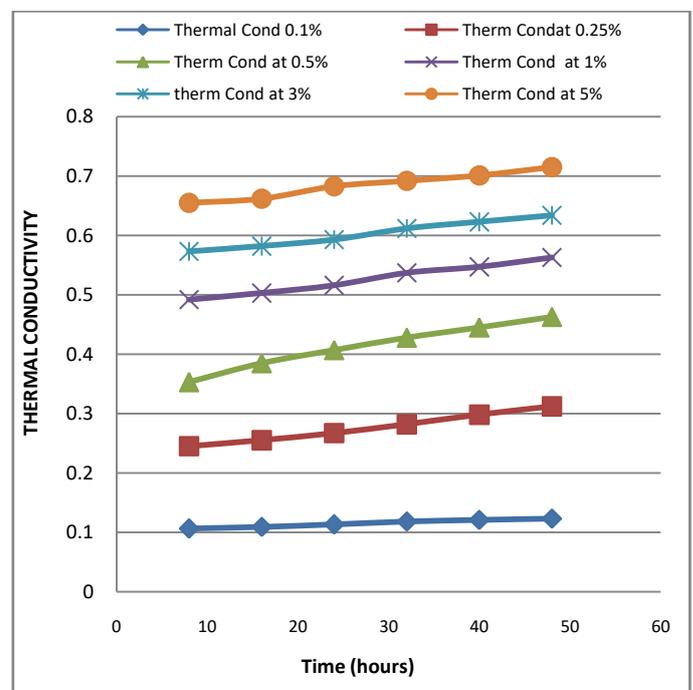
Graph 2 shows Thermal conductivity of Alumina (ALPHA) Nanofluid with base fluid Lubricating oil (320-SZ).

Graph 2 shows that Thermal Conductivity of Alumina (Alpha) Nanofluid with base fluid (320-SZ) exhibit Superior Thermal Properties as compared to Thermal conductivity of lubricating oil (320-SZ). It is due to Superior Nanoparticles properties that Enhances Thermal properties to the Higher level.

Basically Nanofluids are the mixture of nanosized particles (1-100nm) in size; this small particle property plays a greater role in Enhancing Thermal Conductivity.

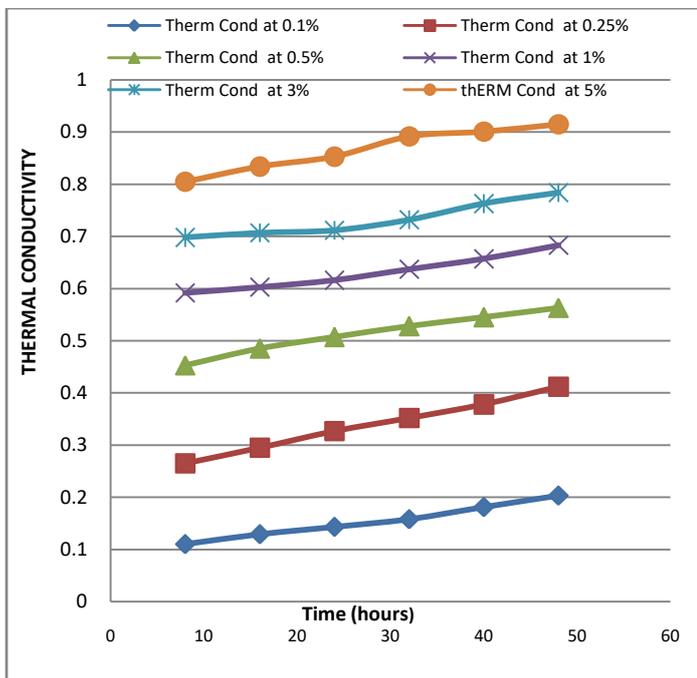
So Result of Graph 1 & Graph 2 is that Alumina (Alpha) Nanofluid with base fluid lubricating oil (320-SZ) Shows better Thermal Conductivity as compared to Thermal Conductivity of base fluid i.e. lubricating oil (320-SZ). So, Thermal Conductivity of Alumina (Alpha) Nanofluid is greater than Thermal Conductivity of Base Fluid i.e (320-SZ).

**Graph 1: Thermal Conductivity of Lubricating Oil (320-Sz) With Respect To Temperature at Various Volume Concentrations**



Graph 1

**Graph 2: Thermal Conductivity of Alumina Alpha Nanofluid with Base Fluid Lubricating Oil (320-SZ)**

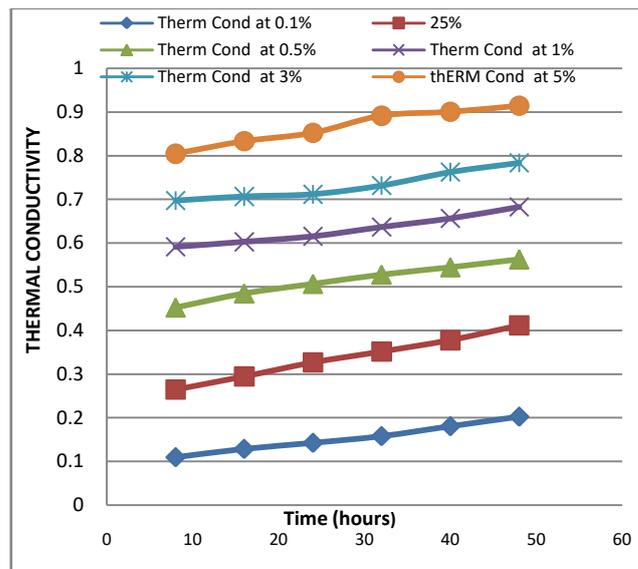


**Graph 2**

Graph 1 shows Thermal conductivity of Lubricating oil (320-SZ) With respect to Temperature at various volume concentrations. For 0.1% Volume concentration the 0.106 to 0.123. For 0.25% Volume concentration at 0.25%, Thermal Conductivity rises from 0.245 to 0.312. Similarly for 5% Volume concentration The Thermal; Conductivity goes from 0.655 to 0.715.

Graph 2 Shows Thermal Conductivity of Alumina (Alpha) Nanofluid with base fluid lubricating oil (320-SZ). Graph II indicates that Thermal Conductivity of Alumina (Alpha) Nanofluid with base fluid lubricating oil (320-SZ) is very much higher than the Thermal Conductivity of Lubricating oil (320-SZ). Reason for it The Thermal properties of Nanofluid that Enhances Thermal Conductivity. Graph II shows at 0.1% Volume concentration Thermal Conductivity goes from 0.11 to 0.203. Similarly for 0.25% Volume concentration goes 0.265 to 0.412. For 5% Volume concentration Thermal conductivity rises from 0.805 to 0.915.

**Graph 3: Thermal Conductivity of Alumina (ALPHA) Nanofluid with Base Fluid I.E Lubricating Oil (320-SZ) With Respect to Temperature at Various Volume Concentrations**



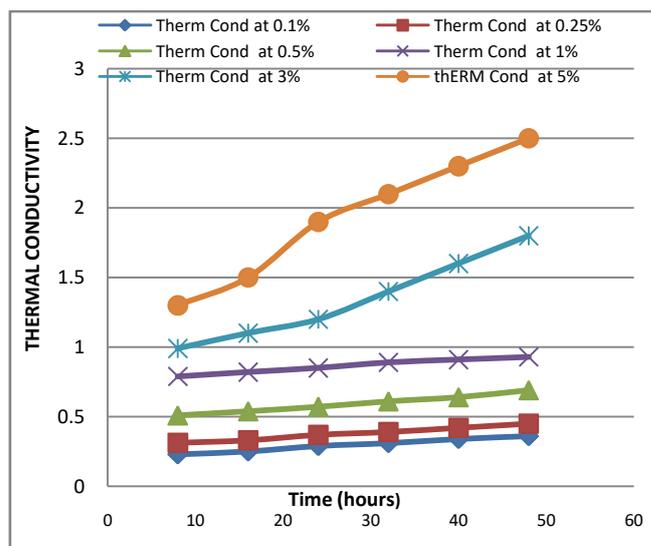
**Graph 3**

The Thermal conductivity at 0.1% volume concentration of lubricating oil (160-MPZ) Falls Between 0.11 to 0.203.

Similarly for 0.25% volume concentration Thermal conductivity falls between 0.265 to 0.412.

For 0.5%, 1%, 3% & 5% Volume concentration range of Thermal conductivity is 0.453 to 0.563, 0.592 to 0.683, 0.698 to 0.784, 0.805 to 0.915.

**Graph 4: Thermal Conductivity of Alumina Alpha Nanofluid with Base Fluid Lubricating Oil (160-MPZ) With Respect to Temperature at Various Volume Concentrations**



**Graph 4**

Graph 4 result indicates at 0.1%, 0.25%, 0.5%, 1%. 3% & 5% Volume concentration Range of Thermal conductivity

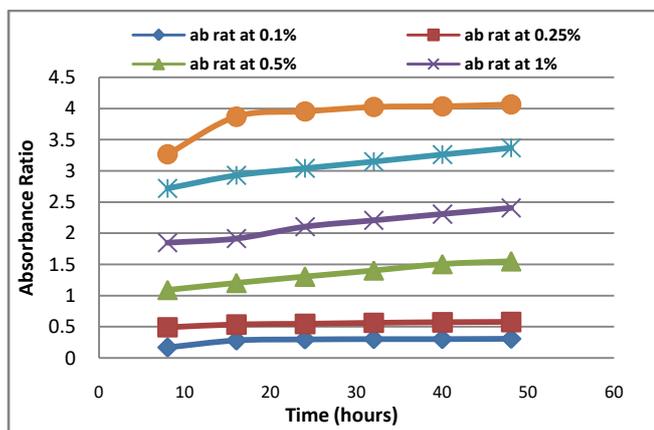
values are 0.23 To 0.36, 0.312 To 0.345, 0.51 to 0.69, 0.79 to 0.93, 0.99 to 1.80, for 1% Volume concentration Thermal Conductivity went from 0.79 to 0.93. Similarly for 3% and 5% Thermal conductivity ranges from 0.99 to 1.8 and 1.3 to 2.5.

From Graph 3 & 4 Comparison of Alumina (Alpha) Nanofluid with base fluid lubricating oil (320-SZ) & (160-MPZ) have been concluded and it has been observed that Alumina (Alpha) nanofluid with lubricating oil (160-MPZ) Shows better Thermal conductivity than Alumina (Alpha) Nanofluid with base fluid lubricating oil (320-SZ).

Reason for Increase in Thermal Conductivity is Alumina (ALPHA) Nanofluid with base Fluid (160-MPZ) as compared to Base fluid (320-SZ) due to the following properties:

- 1) **Concentration:** Higher concentration or weight percentage generally leads to greater Thermal Conductivity enhancement.
- 2) **Particle size:** Nanofluid having smaller particle size lead to greater Thermal Enhancement it depends on other factor also.
- 3) **Temperature:** Nanofluids generally increase with Temperature due to their unique property. Alumina (Alpha) Nanofluid temperature played a key role.
- 4) **Base Fluid:** Selection of base fluid like lubricating oil, water, ethylene glycol lead to greater Thermal Enhancement.
- 5) **Phase:** The phase played a vital role in Thermal Conductivity. Alumina (ALPHA) Phase has a porous structure that results from XRD it contributes to Thermal conductivity
- 6) **Thermo physical properties of lubricating oil (160-MPZ):** Lubricating oil (160-mpz) has greater Thermal physical properties as compared to Thermo physical properties of Lubricating oil (320- SZ).

**Graph 5: Absorption Ratio of Alumina (Alpha) Nanofluid with Lubricating Oil (320-SZ) With Respect to Time**



Graph 5

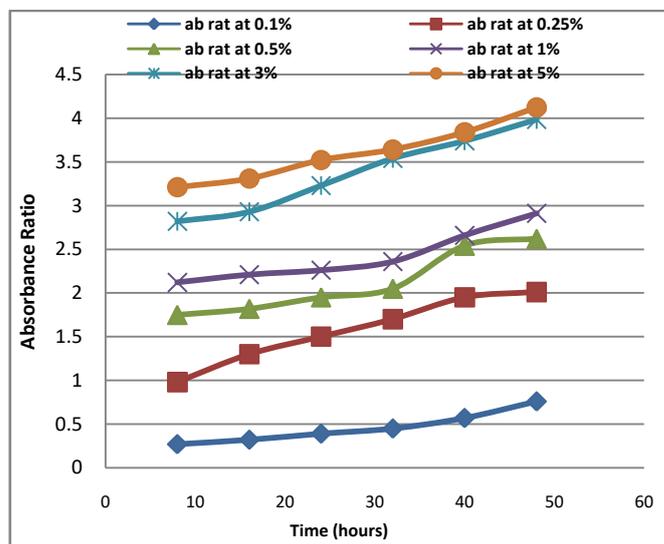
Graph 5 Shows Absorption ratio of Lubricating oil (320-SZ). It indicates there is less absorption ratio of Lubricating oil (160--MPZ). For 0.1% volume concentration the Absorption ratio goes from 0.17 to 0.309. For 0.25 % volume concentration Absorption Ratio goes from 0.492 to 0.578. Similarly for 3% and 5% Volume Concentration Thermal Conductivity goes from 2.717 to 3.369 and 3.267 to 4.064.

Graph 6 Indicates Absorption ratio of Alumina (Alpha) Nanofluid absorption ratio of Alumina (alpha) nanofluid with base fluid lubricating oil (160-MPZ) is higher than Thermal Conductivity of Lubricating oil (160-MPZ). At 0.1, 0.25, 0.5, 1, 3, & 5% Volume concentration Value of Thermal conductivity falls between 0.27 to 0.76, 0.98 to 2.01, 1.75 to 2.62, 2.82 to 3.98, 3.21 to 4.12.

Graph 5 & Graph 6 shows Absorption Ratio of Alumina (Alpha) Nanofluid with base fluid i.e lubricating oil (160-SZ) Shows better Absorption than Alumina (Alpha) Nanofluid with base fluid (320-SZ).

Reason for Higher Absorption Ratio when Base Fluid Lubricating oil (160-MPZ) is mixed with Alumina (Alpha) Nanofluid As compared with Alumina (Alpha) Nanofluid with base fluid lubricating oil (320-SZ).

**Graph 6: Absorption Ratio of Alumina (Alpha) Nanofluid with Base Fluid Lubricating Oil (160-MPZ)**

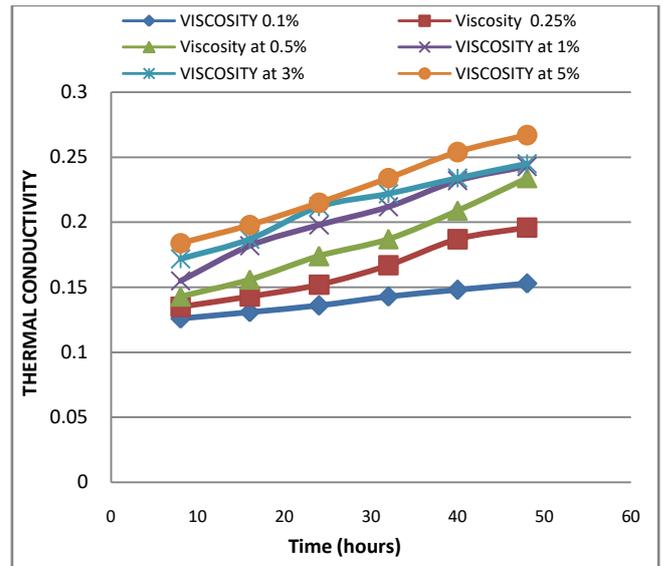


Graph 6

- 1) **Structure:** Alumina (ALPHA) Nanofluid has a Solid structure as compared to Alumina (Gamma) nanofluid that inherit thermal properties which result in better heat transfer enhancement. So Alumina (Alpha) Nanofluid with lubricating oil (160-MPZ) has better Absorption ratio as compared to other Lubricating oil (320-SZ).

- 2) **Phase Porosity:** Phase structure of Alumina (Alpha) nanofluid has higher value of phase fraction and the porosity result in a lower mass based specific heat capacity. Thus generally a sample with a higher fraction of  $\alpha$  phase and a lower porosity possesses a higher thermal conductivity.
- 3) **Easily Dispersed Into Surfactants:** Alumina (Alpha) nanofluid has a property to easily disperse into surfactants. The addition of surfactants to the nanofluid generally increases Thermal conductivity. Result shows that Alumina (Alpha) nanofluid with surfactants enhances thermal conductivity to 13% as compared without surfactants. So this property of Alumina (ALPHA) Nanofluid of dispersion of surfactants to its base fluid lead to the enhancement of Thermal conductivity as compared to Alumina (Gamma) Nnanofluid.
- 4) **Fluid Stability and Agglomeration:** Stability is a great factor in enhancing Thermal conductivity. Nanoparticles can cluster together due to vander Waals forces, which can lead to settling and decreased heat transfer performance. Agglomeration can be mitigated with surface-active agents (surfactants) or by adjusting the nanofluid's PH. So fluid stability and agglomeration plays a vital role in Thermal conductivity. Alumina (ALPHA) nanofluid has better agglomeration that leads to enhancement in Thermal conductivity.
- 5) **Preparation Method:** Preparation method plays a vital role in enhancement of Thermal Conductivity. One step method has a greater tendency for enhancement of Thermal conductivity. So Alumina (Alpha) nanofluid has mostly prepared by one step method that automatically leads to enhancement of Thermal conductivity. Actually one step method has greater Stability, suspension, better agglomeration that leads to great Thermal conductivity.

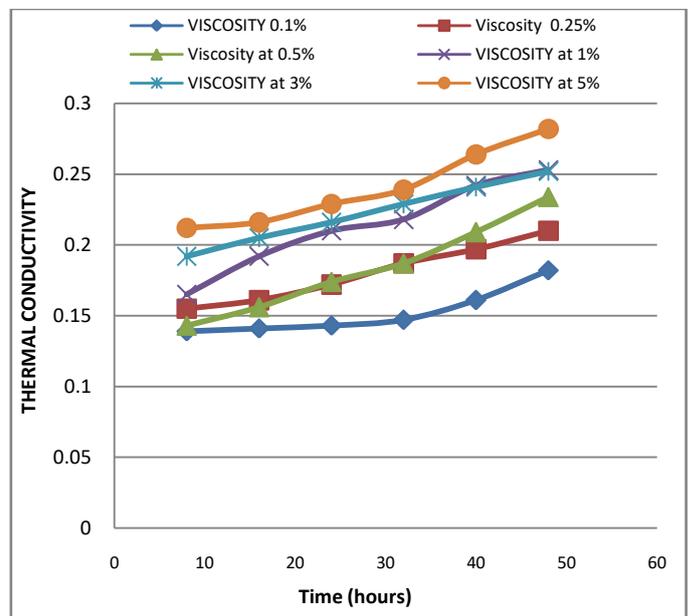
**Graph 7: Shows Effect of Viscosity of Lubricating oil (320-SZ) on Alumina (Alpha) Nanofluids**



**Graph 7**

Viscosity at 0.1, 0.25, 0.5, 1, 3 & 5% volume concentration falls between 0.126 to 0.153. 0.135 to 0.196. 0.143 to 0.155 to 0.234. 0.172 to 0.245. 0.184 to 0.267. For Alumina (Alpha) Nanofluid with base fluid lubricating oil (320-SZ).

**Graph 8: Effect of Alumina (Alpha) Nanofluid with Base Fluid (160-MPZ)**



**Graph 8**

Viscosity at 0.1% volume concentration falls between 0.139 to 0.182.

Viscosity at 0.25% volume concentration lies between 0.155 to 0.210. Viscosity at 0.5% Volume concentration lies under 0.143 to 0.234.

Viscosity at 1%, 3% & 5% Volume concentration lies under 0.165 to 0.253. 0.192 to 0.252. 0.212 to 0.282.

Graph 7 & 8 Concludes that Viscosity of Alumina (Alpha) Nanofluid with base fluid (160-MPZ) is higher than Viscosity of Alumina (Alpha) Nanofluid with base fluid (320-SZ).

## XI. CONCLUSION

From Experimental study of comparison of Thermal Conductivity of  $Al_2O_3$  Alpha Nanofluid with Base fluid Lubricating oil (320-SZ) & (160-MPZ). It is concluded that:

- 1) Thermal Conductivity of Alumina (Alpha) Nanofluid with base fluid (320-SZ) is higher than Thermal Conductivity of base fluid i.e Lubricating oil (320-SZ).
- 2) Thermal Conductivity of Alumina (Alpha) Nanofluid with base fluid (160-MPZ) is higher than Thermal Conductivity of Lubricating oil (160-MPZ).
- 3) Thermal Conductivity of Alumina (Alpha) Nanofluid with base fluid Lubricating oil (160-MPZ) is very much higher than Thermal Conductivity of Alumina (Alpha) nanofluid with Base fluid Lubricating oil (320-SZ).
- 4) Absorption Ratio of Alumina (Alpha) Nanofluid with base fluid Lubricating oil (160-MPZ) is higher than the Absorption Ratio of Alumina (Alpha) Lubricating oil (320-HZ).
- 5) Viscosity of Alumina (Alpha) Nanofluid with Lubricating oil (160-MPZ) is higher than that of Viscosity of Alumina (Alpha) Nanofluid with lubricating oil (320-SZ).

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