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EXPERIMENTAL STUDY ON HEAT TRANSFER ENHANCEMENT USING CNT NANOFLUIDS WITH EMPHASIS ON SAFE NANOMATERIAL HANDLING

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Keywords

Nano fluids, Nanoparticles, Enhancement of Heat Transfer, Friction Factor.

Abstract

Nano fluids refer to fluids which include particles of Nano meter dimensions known as nanoparticles. These fluids contain small particles that are suspended within standard fluids. Nano fluids have experienced worldwide research interest ever since scientists first identified their unexpected thermal Properties. The improvement of heat transfer through Nano fluids serves as a common heat transfer method for various heat transfer applications. Research shows that Nano fluids demonstrate substantial heat transfer improvement while proving ideal for microelectronics, pharmaceutical processing, fuel cells and hybrid engine systems as well as domestic refrigerator, chiller, heat exchanger and boiler flue gas temperature reduction. A comprehensive analysis of heat transfer improvement through Nano fluids and their potential applications is presented in this review. The review paper delivers an updated evaluation of Nano fluid heat transfer applications to guide future research because relevant studies are widely distributed across heat transfer, material science, physics, and chemical engineering and synthetic chemistry disciplines. The modification of thermal and rheological properties in Nano fluids becomes possible through the integration of nanoparticles which leads to better heat exchanger performance. The study investigates how

	nanoparticle features which include concentration and size and shape affect the behaviour of Nano fluids. The thermos physical features of Nano fluids combined with their flow characteristics serve as critical elements to evaluate heat transfer efficiency and pressure loss.

1. INTRODUCTION

The past years have marked Nano fluids as important substances because they demonstrate potential to function as efficient heat transfer fluids for electronic cooling and automotive applications. Researchers achieve better performance in heat transfer systems by researching both increased heat flux and equipment miniaturization. Heat transfer applications in various industries including power generation and microelectronics and heating and cooling processes and chemical processing use water and mineral oil and ethylene glycol as heat transfer media. The heat exchange systems in various applications experience reduced performance and size because common fluids have lower heat transfer capabilities than most solid materials. The thermal conductivities of conventional fluids are several hundred times lower than the solid particles. To improve thermal conductivity fluid, suspension of ultrafine solid particles in the fluid can be a creative idea Different types of particles (metallic, non-metallic and polymeric) can be added into fluids to form slurries. The tiny size of these suspended particles ranging from mile meters to micro meters leads to major problems with flow channel blockages and pipeline damage and increased pressure drops. The introduction of solid particles into these fluids commonly produces flow-related mechanical and physical instability. In particular, these particles exhibit fast settlement rates. The improved thermal conductivity of slurries is offset by their impractical nature because the particles separate too quickly. The distinctive nature of nanotechnology as a revolutionary technology has attracted widespread interest from many fields. The widespread adoption of nanotechnology continues to grow rapidly because it serves multiple functions in different domains which include medical science, agricultural production, engineering applications and industrial processes. The scientific field of nanotechnology investigates the material Features that exist within the Nano meter scale. Management of thermal energy is primarily based on heat exchangers (HX). With the rise in energy costs, there is a growing demand for more efficient heat exchangers to contribute to energy-saving efforts in industries. Researchers are working on new designs and improving the working fluids to make better use of energy consumption. Since conventional fuel sources are limited, increased performance of heat exchangers would result in significant savings in energy consumption. Several types of heat exchangers exist, including plate-type, double-pipe, heat pipes, and mini-channel configurations. However, all these types share a common advantage of compactness and high efficiency. Plate type heat exchangers were initially designed for the dairy industry but are now used in several applications within areas such as heat recovery, HVAC systems, cooling processes, power generation, and refrigeration systems. Double-pipe heat exchangers are prevalent in electricity-generating power plants; heaters and economizers constitute two core components of such systems. These devices are easily clean- able and economical. Portable devices such as laptops and mobile phones have necessitated the evolution of

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miniature or micro channels and heat pipes. While increased heat transfer enhances the efficiency of any heat exchanger, it also may require more pumping power, thus highlighting the importance of finding a balance. Nanotechnology enables scientists to control matter at dimensions that are one-thousandth the size of a micro meter or 109 meters. The potential for thermal conductivity in materials like alumina and titanium oxide enables scientists to develop their Nano sized particle forms. The process combines these Nano sized particles with base fluids to produce a stable colloidal Solution which serves heat transfer functions. The addition of thermal-conductive base fluids enables the enhancement of heat transfer performance characteristics. The innovative product known as Nano fluid stands as one of the most recent achievements in nanotechnology research. The application of Nano fluid generates improved heat transfer capabilities that enable energy savings through reduced equipment size. Understanding the impact of crucial parameters is vital for enhancing heat transfer. Unlike other reviews that focus on specific applications, this one looks at a range of uses for both methods, including solar collectors, car radiators, and nuclear fuel rods, to showcase how factors like particle concentration and flow patterns affect thermal performance. Therefore, conducting this review is essential for advancing knowledge in the field. It primarily aims to improve

Heat transfer coefficients, Nusselt numbers, heat transfer rates, thermal performance factors, and other related enhancements that can be influenced by Nano fluids. By suggesting new paths for exploration, this review hopes to encourage further research that could make a significant impact on heat transfer augmentation. Ultimately, this research could serve as a valuable resource for those looking to understand and improve heat transfer using Nano fluids. Different challenges are offered to Heat engineering applications as a result of an innovative heat transfer medium-Nano fluids. Several important parameters are to be considered while selecting and preparing Nano fluids. Effects of the application of passive methods on HT and pressure drop (p) for heat exchange equipment. Elaboration of the factors playing a major role in improving the heat transfer characteristic of Nano fluids. Different models used to determine the thermodynamic properties of Nano fluids.

2. SYNTHESIS METHODS OF NANOFLUIDS

Scientists have attempted numerous techniques to manufacture distinct nanoparticle forms along with Nano suspension products. Two principal techniques exist for Nano fluid preparation: Two-step production begins with the creation of nanoparticle or nanotube dry powder. After nanoparticle production a fluid is mixed with the particles through dispersion in a second step scientists have developed both single-step and novel methods for Nano fluid production in this section. Small solid particles found in Nano fluids are nanoparticles. Spread throughout the base fluid showing a certain movement. They work as heat carriers, directly conveying October 2023 is when your training data ends. Creating tiny convection currents that improve the effective conductivity of the base fluid thermally. Conversely, mostly hold their atoms below micronized particles. the surface, therefore

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restricting their participation in heat transfer Processes. Several theories including the ideas of heat Conduction in Nano fluids provides understanding that could support verifying mechanisms for improvement using thermal conductance. These comprise nanoparticle Brownian behaviour motion, nanoparticle clustering, liquid formation Nano layer around nanoparticles, ballistic transport and non- local interactions, thermophoresis, and near-field radiation. Though every one of these systems could clarify the rise in thermal conductivity. Significant possibility they might not run consistently over all Nano fluidic systems. This mostly results from the various behaviours shown by many different nanomaterials 1 when interacting with various base fluids.

3. TWO-PHASE METHOD

The most popular method for Nano fluid preparation is the one that dominates industrial use. This method begins with the production of dry powder through chemical or physical methods before converting it into Nano fluids by mixing it with fluids. Subsequently, the Nano-sized powder undergoes processing through a second stage where magnetic force agitation and ultrasonic agitation and high-shear mixing along with homogenizing and ball milling facilitate the dispersion process. Nano powder synthesis techniques at industrial pro- duction levels make the two-step method the most cost- effective approach for Nano fluid large-scale manufacturing. The high surface area and activity of Nano particles lead them to form clumped groups. The most effective method to stabilize Nano particles in fluids involves using surfactants. The performance of surfactants at elevated temperatures creates significant worries especially when dealing with applications operating at high temperatures. The development of advanced techniques became necessary because the two-step method encounters difficulties in producing stable Nano fluids so researchers introduced one step methods. The next section provides details on the single step method.

A. One-Phase Method

During the drying storage and transportation process the nanoparticles tend to form agglomerates which create problems for the two-step dispersion stage. The thermal conductivity and stability of the Nano fluids reach suboptimal levels at present. The process of making Nano fluids incurs high expenses. Various one-step methods emerged as solutions to decrease the agglomeration of nanoparticles. The preparation of Nano fluids in this fashion occurs through direct evaporation condensation as well as chemical vapour condensation and single-step chemical synthesis.

B. Additional Innovative Approaches

• Researchers under the leadership of Wei and his team developed a continuous flow microfluidic micro reactor which produces copper Nano fluids. Through this process researchers can continuously make copper Nano fluids while adjusting specific parameters to control the resulting microstructure and properties including reactant concentration and flow rate and additive levels. A novel precursor transformation approach using ultrasonic and microwave irradiation enables the production of CuO Nano fluids which reach solid volume fractions of 10 vol

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• Microwave irradiation causes complete transformation of precursor Cu(OH)2 into CuO nanoparticles in water. The nanoparticle growth and aggregation are prevented by ammonium citrate which creates a stable CuO aqueous Nano fluid with improved thermal conductivity compared to other dispersing methods. The phase-transfer method stands as a straightforward technique to acquire monodisperse noble metal colloids. Researchers also use the phase transfer method for making stable kerosene-based Fe3O4 Nano fluids. Through the chemisorbed mode process oleic acid successfully attaches to the Fe3O4 nanoparticle surface which creates effective kerosene compatibility. A water cyclohexane two-phase system enables the movement of aqueous formaldehyde into the cyclohexane phase through a dodecyl amine reaction which leads to reductive intermediate formation inside cyclohexane.

• The reductive intermediates produced in cyclohexane operate to reduce silver and gold ions present in aqueous solutions which generates dodecylamine-coated silver and gold nanoparticles under room temperature conditions. The researchers developed an organic phase transfer method in aqueous environments by exploiting the reduced PVP solubility in water at elevated temperatures to create gold, silver, and platinum nanoparticles. The method utilizes a water phase containing organic ions to transfer particles from the organic phase to the aqueous phase. They established a method to produce metal nanoparticles in two-phase systems using water.

C. Benefits of Nano fluids

When Nano fluids combine with base fluids, the resulting changes produce several anticipated advantages. The presence of Nano-sized particles results in minimal reduction of pressure. The thermal conductivity of nanoparticles creates enhanced heat transfer capabilities. The successful implementation of Nano fluids will reduce the weight and dimensions of heat exchangers. The presence of nanoparticles increases the surface area within the base fluid, enhancing heat transfer efficiency. Systems which require quick temperature changes benefit the most from using Nano fluids. The addition of nanoscale particles to base fluids enables the creation of integrated fluid properties. When Nano fluids disperse evenly they enhance heat transfer operations across the entire system. Nano fluids function as superior heat transfer agents which work well in standard applications while showing outstanding results in microchannel systems that require intense heat dissipation. Industries that implement Nano fluids will experience reduced operational expenses through smaller and lighter heat exchangers.

D. Effects of Nano fluids

Microscopic liquid suspensions with small particles in the Nano fluids are main fluids. The total as a result the combination of the environmental effects of Nano fluids Environmental impression of the primary fluid and the nanoscale data up to October 2023 training on particles.H2O's nontoxic, non-flammable, SAFE, and easy-to-use features. You are trained on information up to October 2023. Characteristics, toxic, chemical, and physical nature of the nanoparticles crucially important in establishing the ecological effects footprint of Nano fluids environmentally. The nanoparticles affect

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the environmental impact of Nano fluids. Good environmental management relies on effects of Nano fluids mostly depend on the optimal design of the Nano fluid. Using natural materials such silica, alumina, and iron oxides results in much lesser ecological effects arising from the synthetic production of such particles. This method aids in reducing material and energy. Prerequisites for production. Moreover, using natural usually non-toxic, nanoparticles can help to further reduce possible toxicity issues with application and disposal Nano fluids. Likewise, decreasing the concentration of nanoparticles might help to reduce possible environmental damage. Nano fluids' preparation method greatly affects their environmental footprint. For example, Barberio and colleagues248 evaluated the environmental influence of Nano fluids made from alumina using either a one-step or two- step approach. Based on a combined life cycle, their results Evaluation and risk assessment suggested the one-step approach had almost three times the environmental effect relative to the two-stage method. Nano fluids applied to HT processes enhance environmental benefits by improving them. Improving energy efficiency and hence lowering consumptions, heat loss, and heat dissipation. You are trained on data through October 2023. Lowering emissions of greenhouse gases. Nano fluids have the potential to raise CO_2 absorption that helps to minimize the ecological footprint of carbon emissions contributing to air October 2023 sees training data confluence on pollution. Research on many topics have shown the positive effects on the environment of Nano fluids, including CO_2 sinking using CeO_2/water, solar water heaters' emissions Nano fluids or copper nanoparticles.

4. LITERATURE REVIEW

• B. Farajollahi et al (2010) experimentally investigated the Heat transfer characteristics of -Al_2O_3/water and TiO_2/water Nano fluids were measured in a shell and tube heat exchanger under turbulent flow condition. The effects of Peclet number, volume concentration of suspended nanoparticles, and particle type on the heat characteristics were investigated. Based on the results, adding of nanoparticles to the base fluid causes the significant enhancement of heat transfer characteristics. For both Nano fluids, two different optimum nanoparticle concentrations exist. Comparison of the heat transfer behaviour of two Nano fluids indicates that at a certain Peclet number, heat transfer characteristics of TiO_2/water Nano fluid at its optimum nanoparticle concentration are greater than those of -Al_2O_3/water Nano fluid while cAl_2O_3/water Nano fluid possesses better heat transfer behaviour at higher nanoparticle concentrations.

• Saeed Zeinali Heris (2011) studied the boiling heat transfer performance of Nano fluid. Some controversial results are reported in literature about the potential impact of Nano fluids on heat transfer intensification. Whereas the mixtures of ethylene glycol and water are considered the most common water- based anti freeze solutions used in automotive cooling systems, the present study is an experimental investigation of boiling heat transfer of CuO/ethylene glycol–water (60/40) Nano fluids. The results indicate that a considerable boiling heat transfer enhancement has been achieved by Nano fluid and the enhancement increases with nanoparticles concentration and reaches 55

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• M.Saeedinia (2012) carried out an experimental study to investigate the heat transfer and pressure drop characteristics of CuO/Base oil Nano fluid laminar flow in a smooth tube with different wire coil inserts under constant heat flux.

• Gabriela Huminic (2012) experimentally investigated on the enhancement of the convection heat transfer in heat exchangers using Nano fluids. The first section focuses on presenting the theoretical and experimental results for the effective thermal conductivity, viscosity and the Nusselt number reported by several authors. The second section concentrates on application of Nano fluids in various types of heat exchangers: plate heat exchangers, shell and tube heat exchangers, compact heat exchangers and double pipe heat exchangers.

• N.Kannadasan (2012) compared heat transfer and pressure drop characteristics of CuO/water nanofluids in a helically coiled heat exchanger held in horizontal and vertical positions is presented.

• T.Srinivas (2013) evaluated the performance of an agitated helical coil heat exchanger using Al2O3/water Nano fluid in terms of the energy consumed to heat another fluid. The comparison has been made when Nano fluid and base fluid (water) are used as heating medium. The studies have been carried out using Al2O3/water Nano fluid of different concentrations, flow rates, stirrer speeds and shell-side fluid (heating medium) temperatures. It has been observed that, energy savings are more in laminar and turbulent conditions of flow than transition regime, and percentage savings increase with increase in nanoparticle concentration. Higher stirrer speed and shell-side fluid temperature also resulted in more energy savings. In addition, use of Nano fluid resulted in heating the coil- side fluid (water) to higher outlet temperature.

• L.Syam sundar (2013) studied the Viscosity an important property particularly concerning fluids flowing in a tube in heat exchangers. In this regard, an attempt has been made to review the available empirical and theoretical correlations for the estimation of viscosity of Nano fluids. Their view also extended to preparation of Nano fluids, nanoparticle volume concentration, Nano fluid temperature, particle size and type of base fluid on viscosity of Nano fluids. The available experimental results clearly indicate that with the dispersion of nanoparticles in the base fluid viscosity increases and it further increases with the increase in particle volume concentration. Viscosity of Nano fluid decreases with increase of temperature.

• l.Godson et al (2014) carried out an experiment to investigate the heat transfer characteristics of silver/ water Nano fluids in a shell and tube heat exchanger. The test matrix is worked out in the turbulent regime with Reynolds number varying between 5000 and 25,000.

E. Nano fluid Applications

Improvement of heat transfer and energy Nano fluids may find application in effectiveness across many thermal systems. Means can be applied as cooling fluids in several uses some widespread use:

1. Engine cooling.
2. Cooling system for nuclear
3. Cooling of electronic circuit

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4. Cold storage
5. Improving heat transfer exchange
6. Therma l storage
7. Biomedicine's use possible.
8. Microchip cooling.
9. In defines and space uses Transportation.
11. Petroleum sector.
12. Inkjet printing.
13. Environmental remediation.
14. Surface coating.
15. Fuel additives.
16. Lubricant.

5. CONCLUSION

This study explores the most recent developments in the devilment Nano fluid properties of stability, heat, effectiveness, and in thermal systems. The review of the literature reveals a number of important results on the recent development of Nano fluid were obtained technology Research up to October 2023 has found that adding nanoparticles into Thermal prop retires including hm, kp, base fluids can improve, affecting variables including f, Re, Nu, and pump October 2023 marks the limit of your training data. Nano fluids find use in several contexts depending on their characteristics and best temperature conditions— Improved THP depends on several factors: temperature, and particle size. You are taught on data through October 2023. Nano fluids whose heat capacity exceeds that of the base fluid improves thermal system performance. Further more important in design is thermodynamic performance using heat treatment systems and exergy efficiency together with entropy generation being critical factors dependent on the kind of nanoparticle, thermal application, kind of flow regime, and. Rising thermal efficiency lessens system energy, lower pressure uses and lowers exergy destruction. Fewer studies on this topic have been published. On the thermo-economic performance of Nano fluids, necesciting additional studies examining and refining the cost Nano fluid performance for improved thermal applications. Nano fluids' improved kt and lowered viscosity create them ideal for high-temperature uses, hence HT area expansion and possible size and weight reductions in thermal systems. Nano fluids might find different uses in October 2023 is the latest data cut-off for your training. Sectors. The shape of additives greatly affects the qualities Nano fluids' Looking into novel methods for synthesize- using Nano fluids for exact control over microscopic structures research avenues abound. Suspensions' stability is of utmost relevance in theoretical studies as well as practical applications. This includes unchanging stability over extended durations and thermal cycles requiring increased Training on data through October 2023.

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6. AUTHOR(S) CONTRIBUTION

The writers affirm that they have no connections to, or engagement with, any group or body that provides financial or non-financial assistance for the topics or resources covered in this manuscript.

7. CONFLICTS OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

8. PLAGIARISM POLICY

All authors declare that any kind of violation of plagiarism, copyright and ethical matters will take care by all authors. Journal and editors are not liable for aforesaid matters.

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REFERENCES

[1] Masuda H, Ebata A, Teramae K, Hishinuma N. Alteration of thermal conductivity and viscosity of liquid by dispersing ultrafine particles (dispersion of c-Al2O3, SiO2, and TiO2 ultra-fine particles). Netsu Bussei 1993.

[2] Choi SUS. Enhancing thermal conductivity of fluids with nanoparticles.ASME Fluids Eng Div (Publ) 1995.

[3] Baughman RH, Zakhidov AA, de Heer HA. Carbon nanotubes—the route towards applications. Science 2002.

[4] Coleman JN, Khan U, Blau WJ, Gunko YK. Small but strong: A review of the properties of carbon nanotube polymer composites. Carbon 2006.

[5] Nuriel S, Liu L, Barber HA, Wagner HD. Direct measurement of nanotube surface tension. Chem Phys Lett 2005.

[6] Rashmi W, Ismail, AF Sopyan I, Jameel AT, Yusof F, Khalid M, Mujawar M. Stability and thermal conductivity enhancement of carbon nanotube (CNT) nanofluid using gum Arabic. J Experi Nanosci, iFirst 1-13 2011;(DOI:10.1080/ 17458080.2010.487229).

[7] Maxwell JC. A treatise on electricity and magnetism. Clarendon Press; 1873.Hamilton RL, Crosser OK. Thermal conductivity of heterogeneous two- component systems. Ind Eng Chem Fundam 1962.[9] Jeffrey DJ. Conduction through a random suspension of spheres. Proc Royal Soc London 1973.

[8] Patel HE. Experimental and theoretical investigation on thermal con- ductivity enhancement of nanofluids. PhD Thesis, Indian Institute of Technology Madras Chennai, India, 2004.

[9] Hansen JP, McDonald IR. Theory of simple liquids. Academic Press; 1976.

[10] Einstein A. U¨ ber Die Von Der MolekularkinetischenTheorie Der Wa¨rme Geforderte Bewegung Von In Ruhenden Flu¨ssigkeiten Suspendierten Teilchen. Annalen der Physik 1905.

[11] Shukla RK, Dhir VK. Study of the effective thermal conductivity of nanofluids. In: Proceedings of IMECE 2005 ASME International Mechanical Engineering Congress And Exposition, Orlando, Florida, USA, 2005.

[12] Dhont JKG. An introduction to dynamics of colloids. 2 Elsevier Nether- land; 2003.

[13] Xie H, Lee H, Youn W, Choi SUS. Nanofluids containing multiwalled carbon nanotubes and their enhanced thermal conductivities. J App Phy 2003.

[14] Wen D, Ding Y. Experimental investigation into convective heat transfer of nanofluids at the entrance region under laminar flow conditions. Int J Heat Mass Transfer 2004.

[15] Hwang Y, Lee JK, Lee CH, Jung YM, Cheong SI, Lee CG, Ku BC, Jang SP. Stability and thermal conductivity characteristics of nanofluids. Thermochim Acta 2007.

[16] A. S. Dalkilic et.al' Forced Convective Heat Transfer of Nanofluids- A Review of the Recent Literature' Current Nanoscience, 2012, 8, 949-969.

[17] C. Yang, W. Li, A. Nakayama, 'Convective heat transfer of Nanofluids in a concentric annulus' 'International Journal of Thermal Sciences' 71 (2013) 249-257.

[18] Y. Raja Sekhara, K. V. Sharmab, R. Thundil Karupparaja, C. Chiran- jeevia 'Heat Transfer Enhancement with Al2O3 Nanofluids and Twisted Tapes in a Pipe for Solar Thermal Applications' 'International Confer- ence On DESIGN AND MANUFACTURING, IConDM 2013'Procedia Engineering 64 (2013) 1474 – 1484.

[19] Adnan M. Hussein, K. V. Sharma, R. A. Bakar, and K. Kadirgama.'The Effect of Nanofluid Volume Concentration on Heat Transfer and Fric- tion Factor inside a Horizontal Tube' Hindawi Publishing Corporation 'Journal of Nanomaterials' Volume 2013, Article ID 859563, 12 pages.

[20] X. Feng, H. Ma, S. Huang et al., "Aqueous-organic phasetransfer of highly stable gold, silver, and platinum nanoparticles and new route for fabrication of gold nanofilms at the oil/water interface and on solid supports," Journal of Physical Chemistry B, vol. 110, no. 25, pp. 12311–12317, 2006.

[21] W. Yu, H. Xie, L. Chen, and Y. Li, "Enhancement of thermal conduc- tivity of kerosene-based Fe3O4 nanofluids prepared via phase-transfer method," Colloids and Surfaces A, vol. 355, no. 1–3, pp. 109–113, 2010.

[22] Chen and X. Wang, "Novel phase-transfer preparation of monodisperse silver and gold nanoparticles at room temperature," Materials Letters, vol. 62, no. 15, pp.2215– 2218, 2008.

[23] H. T. Zhu, C. Y. Zhang, Y. M. Tang, and J. X. Wang, "Novel syn- thesis and thermal conductivity of CuO nanofluid," Journal of Physical Chemistry C, vol. 111, no. 4, pp. 1646–1650, 2007.

[24] V. Srdic, M. Winterer, A. Mller, G. Miehe, H. Hahn, J. Am. Ceram. Soc. 84 (2001)277.

[25] A. Eastman, S. U. S. Choi, S. Li, G. Soyez, L. J. Thompson, R. J. DiMelfi, J. Metastab. Nanocryst. 2(1998) 629.

[26] Bayram Sahin, Eyuphan Manay and Eda Feyza Akyurek" An Ex- perimental Study on Heat Transfer and Pressure Drop of CuO-Water Nanofluid" Hindawi Publishing Corporation, Journal of Nanomaterials, Volume 2015, Article ID 790839, 10 pages.

[27] Abdolbaqi Mohammed Khdher, Rizalman Mamat, Nor Azwadi Che Sidik" The Effects of Turbulent Nanofluids and Secondary Flow on the Heat Transfer through a Straight Channel" Recent Advances in Mathematical and Computational Methods, 2015.bibitemb9Dr. Khalid Faisal Sultan" Augmentation of Heat Transfer through Heat Exchanger With and Without Fins by Using Nano fluids" Journal of Engineering and Development, Vol. 19. No. 4, July 2015, ISSN 1813- 7822.