A Comparative Study of Performance of Heat Transfer Function of a Radiator using Water, Coolant and Nanofluid

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Abstract: In the present work, heat transfer performance of radiator (Heat Exchanger) was studied as a function of heat transfer by using water, engine coolant and Al_2O_3-water nanofluid. The Al_2O_3-water nanofluid was characterized by X-ray diffraction, scanning electron microscope and ultraviolet-visible spectroscopy. The Al_2O_3 nano particles with specification of 2.5 wt% concentration, cubic size and 60 min. probe sonication were used. The mass flow rate of all the three coolants is kept in the range of 0.5 to 5 lit/min, regulated by Rotameter. Temperature difference at inlet and outlet of Radiator (Heat Exchanger) is recorded for all the three coolants with the help of Thermostat. The temperature difference versus discharge graph plotted for water, engine coolant and nanofluid revealed that the highest heat transfer (thermal conductivity) is for Nanofluid followed by coolant and water. The enhancement in thermal conductivity reflects that the nanofluids could be appropriate for cooling applications.

Keywords- *Heat Transfer; Nanofluid; Ultrasonication*

I. INTRODUCTION

The boom in advanced technological applications and its miniaturization in the field of electronics and thermal systems, sought the need of efficient heat transfer systems. The optimized design and improved thermal properties of fluid can provide the positive solution in improving efficiency. Heat transfer is an important area of study in thermal engineering. Selection of a suitable heat transfer fluid for heat dissipation is an important consideration in the thermal design of heat exchangers. Heat transfer of fluid is one of the critical parameters which affect the cost and size of heat exchanger systems. Conventional fluids like water and oil have limited heat transfer capabilities. The need for development of new kinds of fluids with improved heat transfer capabilities is being felt by different research groups across the world. The advances in nanotechnology have made it possible to manufacture metal and metal oxide particles on nano dimensional scale. Nano particles are considered to be new generation material having potential applications in the area of heat transfer.

The nanofluids on the other hand offer many advantages over the single phase pure fluids and suspensions with micro particle. The problems of particle sedimentation due to gravity, clogging of micro channel passage, and erosion of tube material are minimized to a great extent when nanofluids are used in heat exchangers. Besides, nanofluids form stable suspensions with uniform dispersion of nano particles in the base fluid. Thermo physical properties of single phase heat transfer fluids such as water, oils and glycols are well established and are available in literature and hand books. The thermo physical properties of two phase nanofluids are not explored much. Nanofluids are considered to be an alternate and new generation liquids for transport of heat energy and can be employed as heat transfer fluids in heat exchangers in place of pure single phase fluids. The applications of nanofluid in heat transfer include radiators in automotive, chemical engineering and process industries, solar water heater, refrigeration, cooling of electronics devices. The main objective of obtaining heat transfer enhancement using nanofluids is to accommodate high heat fluxes and hence to reduce the cost and size of the heat exchangers which in turn results in conservation of energy and material.

II. EXPERIMENTAL SETUP

In the present work, distilled water and engine coolant were purchased from the market and Al_2O_3 nano particles were procured from the Sigma-Aldrich (India) of analytical grade and used without further purification. The nanofluids were prepared by ultra-sonication technique (PCi-750F). The Al_2O_3 dispersed water samples were kept for the different interval of time under ultra-sonication. Figure 1 shows the schematic diagram of Radiator as a Heat Exchanger.

Instrumentation system was designed to measure fluid discharge, temperature of inlet and outlet fluid, water quantity etc. Figure 2 shows the pictorial view of the designed instrumentation for experimental set up. Fluid Pump, Thermocouples, Radiator Fan, Rotameter, Switch Board, Heater, Radiator and Water Tank are used as standard instrumentation.

The graph of ΔT and discharge is plotted and is shown in fig. 3.

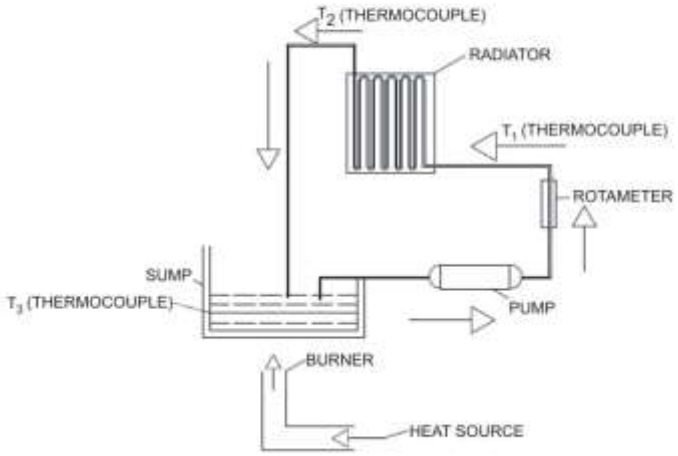

Figure.1. Schematic Diagram of Radiator as a Heat Exchanger.

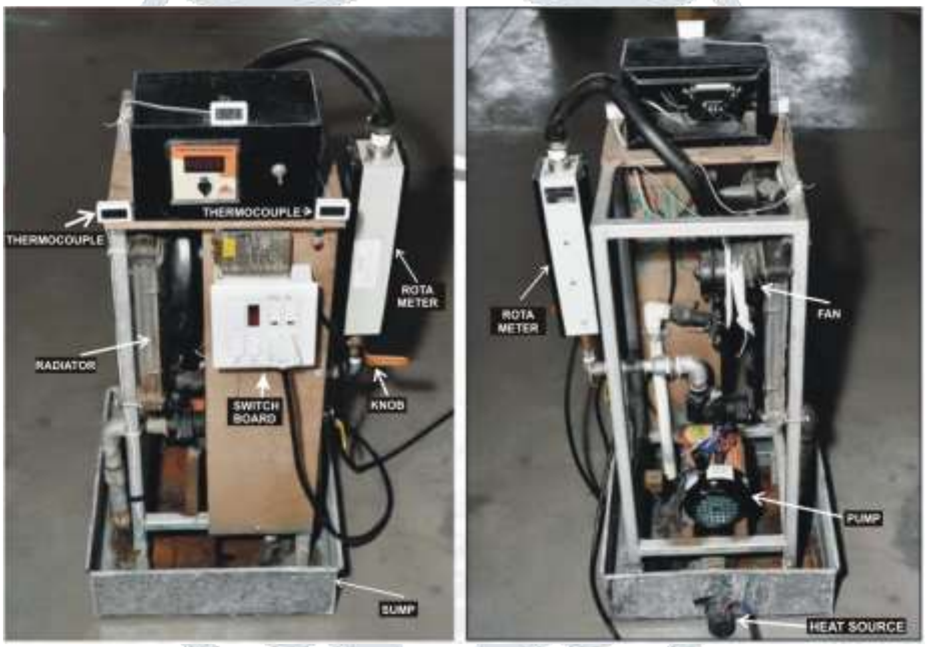

Figure.2. Pictorial View of Designed Instrumentation for Experimental Setup

III. EXPERIMENTAL PROCEDURE

Here, Radiator as a Heat Exchanger experimental setup uses water, engine coolant and Al_2O_3 - water nanofluid one by one as fluid under investigation. Mass flow rate readings are taken in the range of 0.5 to 5 lit/min (with the step of 0.5). The brief procedure is as under:

1. Readings of temperature difference ΔT are taken for water, engine coolant and nanofluid.
2. Readings for Al_2O_3-water nanofluid at 0.5, 1.0, 1.5, 2.0 and 2.5 wt % concentration, 60 min. probe sonication (for size) and cubic shape nanoparticles are tabulated.
3. Readings for Al_2O_3-water nanofluid at 2.5 wt % concentration, cubic shape nanoparticles at 15, 30, 45 and 60 min probe sonication (size) are tabulated.
4. Readings for Al_2O_3-water nanofluid at 2.5 wt % concentration, 60 min probe sonication (size) and cubic, spherical and cylindrical (rod) shape nanoparticles are tabulated.

The present work is focussed on the first part only i.e. the values of temperature difference (ΔT) are recorded for the three coolants (Water, Engine Coolant and Al_2O_3-water nanofluid) at different values of coolant discharge ranging from 0.5 to 5 lit/min (with the step of 0.5).

IV. RESULTS AND DISCUSSION

The experimentation was carried out and the various readings of temperature were recorded at sink (acts as engine) inlet and outlet of radiator. This is done in all the three cases of coolant that is water, engine coolant and Nano fluid. The observations are recorded in table 1 shown below.

The table 1 shows that the values of temperature difference decrease with the increase in coolant discharge for all the three coolants (Water, Engine Coolant and Al_2O_3-water Nano fluid) under consideration for investigation. Fig.3 reveals that the curves drawn in grey, red and blue color indicate three coolants under consideration i.e. water, engine coolant and Al_2O_3-water Nano fluid respectively. These curves also indicate that the temperature difference ΔT values are maximum for Nano fluid followed by coolant and water. Another discussion which comes to the fore from these curves is that the highest value of ΔT is recorded at mass flow rate of 0.5 lit/min and lowest at 5 lit/min in all the three cases. The discussion on results shown in table 1 and figure 3 give an important finding that the highest heat transfer (thermal conductivity) is because of Nano fluid followed by coolant and water.

Table 1. Water, Coolant & Nanofluid Average ΔT *Vs* Discharge

	DISCHARGE	AVERAGE OF DIFFERENCE OF TEMP		
		WATER	COOLANT	NANO FLUID (2.5 wt%, 60 MIN, CUBIC)
1	0.5	8.56	9.45	16.52
2	1	8.2	8.62	13.26
3	1.5	7.14	8.52	13.5
4	2	6.66	6.82	12.9
5	2.5	5.78	5.88	10.4
6	3	4.94	6.04	9.26
7	3.5	5.15	5.62	9.04
8	4	4.34	4.6	7.58
9	4.5	4.38	4.42	7.1
10	5	3.9	4.26	6.62

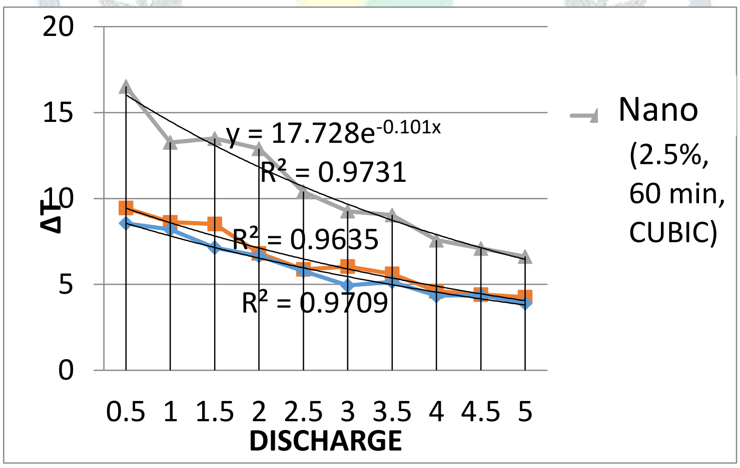

Figure.3. Graph Showing ΔT *Vs* Discharge.

V. CONCLUSIONS

Table 1 depicts the average values of inlet and outlet (radiator) temperature difference against the mass flow rate (0.5 to 5 lit/min) for Water, Coolant and Nanofluid. Fig.3 reveals that:

1. The temperature difference ΔT values are maximum for nanofluid followed by coolant and water.
2. The highest value of ΔT is observed at mass flow rate of 0.5 lit/min and lowest at 5 lit/min in all the three cases.

These two statements conclude that the highest heat transfer (thermal conductivity) is because of Nanofluid followed by coolant and water.

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REFERENCES

[1] Z. Said, R. Saidur, N.A. Rahim, "Optical properties of metal oxides based nanofluids," Int. Comm.in Heat and Mass Transfer, vol. 59, pp. 46–54, December 2014.

[2] L. Colla, L. Fedele, M. Scattolini, S. Bobbo, "Water-based Fe_2O_3 nanofluid characterization: thermal conductivity and viscosity measurements and correlation," Adv. Mechanical Engineer., vol. 2012, pp. 1-8, September 2011.

[3] T.T. Baby, R. Sundara, "Synthesis and transport properties of metal oxide decorated graphene dispersed nanofluids," J. Phys. Chem. C, vol. 115, pp. 8527–8533, April 2013.

[4] R.A. Bhogare, B.S. Kothawale, "A review on applications and challenges of nano-fluids as coolant in automobile radiator," Int. J. Scientific and Res. Publications, vol. 3, pp. 1-11, August 2013.

[5] D. Anandan, K.S. Rajan, "Synthesis and stability of cupric oxide-based nanofluid: A novel coolant for efficient cooling," Asian Journal of Scientific Research, vol. 5, pp. 218-227, April 2012.

[6] V. Sridhara, L.N. Satapathy, "Al_2O_3-based nanofluids: a review," Nanoscale Research Letters, vol. 6, pp. 456-472, July 2011.

[7] K.R. Nemade, S.A.Waghuley, "Low temperature synthesis of semiconducting α-Al_2O_3 quantum dots," Ceramics Int., vol. 40, pp. 6109–6113, May 2014.

[8] I.M. Krieger, T.J. Dougherty, "A mechanism for non-newtonian flow in suspensions of rigid spheres," Trans Soc Rheol., vol. 3, pp. 137–152, August 1959.

[9] P Keblinski, S.R. Phillpot, S.U.S. Choi, J.A. Eastman, "Mechanisms of heat flow in suspensions of nano-sized particles (nanofluids)," Int. J. Heat Mass Transf., vol 45, pp. 855–863, February 2002.

[10] P. B. Maheshwary, C. C. Handa, K. R. Nemade, "A comprehensive study of effect of concentration, particle size and particle shape on thermal conductivity of titania/water based nanofluid," Applied Thermal Engineering (ELSEVIER)., 119 (2017), pp. 79–88, March 2017.

[11] P. B. Maheshwary, C. C. Handa, K. R. Nemade, "Efffect of shape on thermophysical and heat transfer properties of ZnO/R134a nanorefrigerant," Materials Today Proceedings (ELSEVIER)., 5 (2018), pp. 1635–1639.

[12] P. B. Maheshwary, K. R. Nemade, "Enhancement in Heat Transfer performance of ZrO2/H2O Nanofluid via Ultrasonication Time", International Journal on Recent and Innovation Trends in Computing and Communication, ISSN: 2321–8169 Volume: 3, Issue: 2, pp. 035-037 (2015).

[13] P. B. Maheshwary, K. R. Nemade, "Thermal Conductivity Enhancement in MgO Based Nanofluid", 4th Bhartiya Vigyan Sammelan 2015, 5-8 Feb. 2015 at University of Goa (India).

[14] P. B. Maheshwary, C. C. Handa, K. R. Nemade, "Effect of concentration and further enhancement in Thermal Conductivity by addition of copper in ZnS Nanofluid" International Conference on Advances in Thermal Systems, Materials and Design Engineering (ATSMDE – 2017), 21-22 December 2017 at Veermata Jijabai Technological Institute, Mumbai (India) in collaboration with AICTE and TEQIP-III.

[15] P. B. Maheshwary, C. C. Handa, K. R. Nemade, "Enhancement of Thermal Conductivity of Titania Nanofluid via Altering Concentration and Particle Size", International Conference on Nanomaterials and Nanotechnology- NANO 2015, 7-10 December 2015, K S Rangaswamy College of Technology, TN (India).