

**Heat transfer enhancement by using Alumina-Water Nano fluid in a chiller**S.G.Awchar¹, Prof. K.M. Watt²¹Mechanical Engineering, PRMIT&R, Badnera²Mechanical Engineering, PRMIT&R, Badnera

Abstract- In the throat cutting era of competition which has its base in research and development every concept of energy conversion is subjected to improvisation. With a view of above recent trend the performance of various thermal equipments are subjected to research and development so as to increase the energy conversion from one form of energy to another form. The following work represents research in the field of heat exchanger and specifically indicating transfer of heat from higher to lower temperature. Since various fluids have been used to attend higher heat transfer, the more efficient fluid is Nano fluid. In the present work the performance test on chiller unit had been carried out by using Nano fluid. Water based Al₂O₃ (Alumina) has used as a coolant. The Nano fluid was prepared by using different composition of water and Al₂O₃ nanoparticles and it used as the working fluid. The performance has checked by varying the flow rate of Nano fluid in the condenser.

Keywords- Heat exchanger, Nano fluids, Chiller, Al₂O₃ (Alumina)

I. INTRODUCTION

Nano fluids are a new class of fluids engineered by dispersing nanometre-sized materials (Nano-particle, Nano-fibres, Nano-tubes, Nano-wires, Nano rods, Nano sheet, or droplets) in base fluids. In other words, Nano fluids are Nano scale colloidal suspensions containing condensed nanomaterial. They are two-phase systems with one phase (solid phase) in another (liquid phase). Nano fluids have been found to possess enhanced thermo physical properties such as thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients compared to those of base fluids like oil or water. It has demonstrated great potential applications in many fields.

Adding small particles into a fluid in cooling and heating processes is one of the methods to increase the rate of heat transfer by convection between the fluid and the surface. In the past decade, a new class of fluids called Nano fluids, in which particles of size 1–100 nm with high thermal conductivity are suspended in a conventional heat transfer base fluid, have been developed. It has been shown that Nano fluids containing a small amount of metallic or non-metallic particles, such as Al₂O₃, CuO, Cu, SiO₂, TiO₂, have increased thermal conductivity compared with the thermal conductivity of the base fluid. In this work, effective thermal conductivity models of Nano fluids are reviewed and comparisons between experimental findings and theoretical predictions are made. The results show that there exist significant discrepancies among the experimental data available and between the experimental findings and the theoretical model predictions.

In nanotechnology, a particle is defined as a small object that behaves as a whole unit with respect to its transport and properties. Particles are further classified according to diameter. Coarse particles cover a range between 2,500 and 10,000 nanometres. Fine particles are sized between 100 and 2,500 nanometres. Ultrafine particles, or nanoparticle, are between 1 and 100 nanometres in size. The reason for this double name of the same object is that, during the 1970-80s, when the first thorough fundamental studies with "nanoparticles" were underway in the USA (by Granqvist and Buhrmann) and Japan, (within an ERATO Project) they were called "ultrafine particles" (UFP). Nanoparticles may or may not exhibit size-related properties that differ significantly from those observed in fine particles or bulk materials. Although the size of most molecules would fit into the above outline, individual molecules are usually not referred to as nanoparticles [7].

The main driving force for Nano fluids research lies in a wide range of applications. Although some review articles involving the progress of Nano fluid investigation were published in the past several years (Wei Yu and Huaqing Xie, 2012; Adnan Hussein et al.[1], 2013; Akhtari et al.[2], 2013; Jaafar Albadr et al.[3], 2013; Sayantan Mukherjee and Somjit Paria, 2013,[5]; and most of the reviews are concerned of the experimental and theoretical studies of the thermo physical properties or the convective heat transfer of Nano fluids. The purpose of this paper will focus on the new preparation methods and stability mechanisms, especially the new application trends for Nano fluids in addition to the

heat transfer properties of Nano fluids. We will try to find some challenging issues that need to be solved for future research based on the review on these aspects of Nano fluids.

II. EXPERIMENTAL SET UP AND PROCEDURE

The figure shows a schematic diagram of the experimental setup.

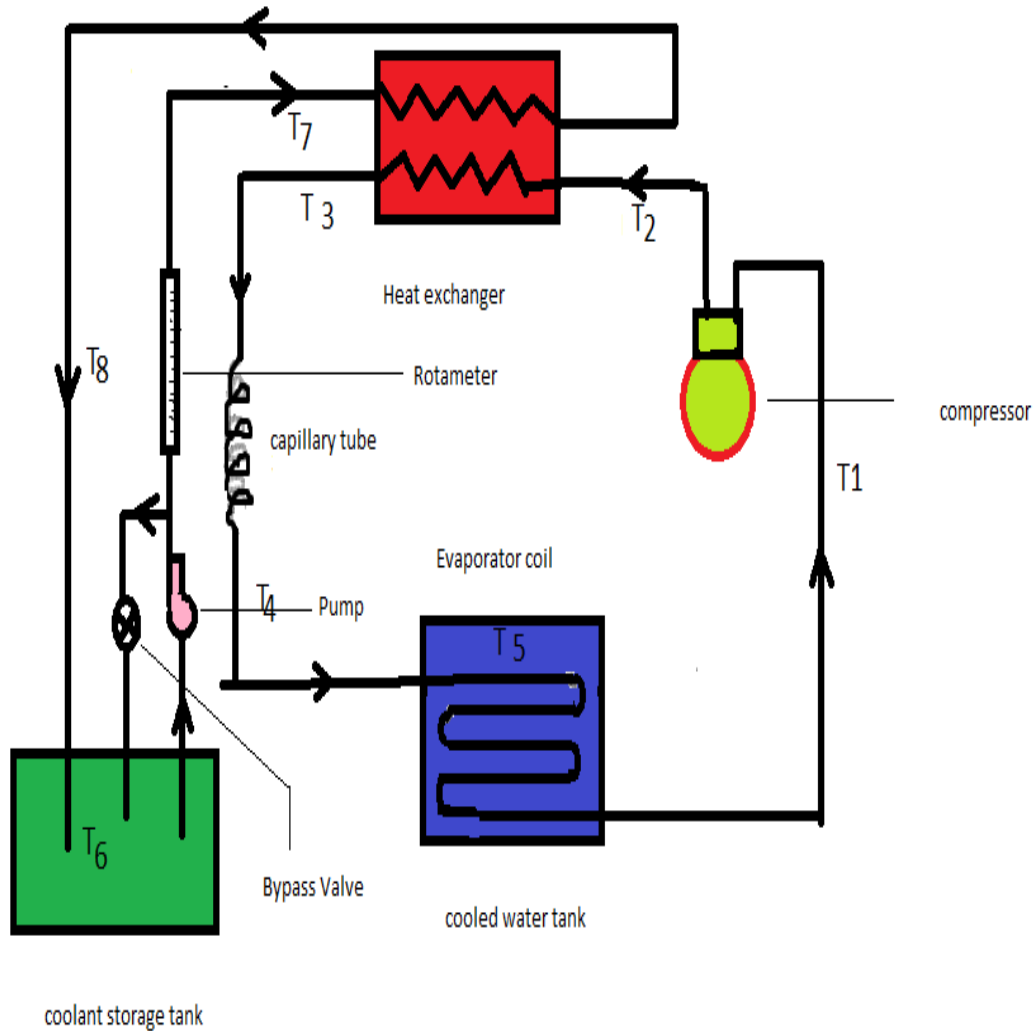


Fig. 1 Flow diagram of chiller Plant

2.1 Experimental Procedure:

- The process flow diagram is shown in figure. This system consists of a plate type heat exchanger, rota meter, magnetic pump, cooling water tank, water storage tank, and vapour compression system.
- The rota meter is provided to measure the flow of fluid.
- The volume flow rate of the fluid can be varied with changing the position of bypass valve.
- The fluid then enters into the heat exchanger first, which has two inlets and two outlets.
- One inlet for coolant and one for hot refrigerants.
- One outlet for passing hot coolant and one for cooled refrigerant.
- The temperature sensor T1- fitted at the compressor inlet.
- T2- fitted at outlet of compressor.
- T3- fitted before capillary tube.
- T4-fitted after capillary tube.

- T5 – fitted at the cooling water tank.
 - T6- fitted where coolant will pass through heat exchanger.
 - T7- fitted at inlet of heat exchanger at coolant side.
 - T8- fitted at the outlet of heat exchanger
- The effective thermal conductivity is calculated by taking the difference in temperatures. Sensors are connected to the digital temperature indicator. The procedure is as follows:
- The set-up is first dry run to ensure complete removal of air/water bubbles in the heat exchanger tubes as well as in the pump.
 - The fluid to be tested is filled in the storage tank up to a certain required level.
 - The fluid (normal water) to be cooled is filled in another storage tank.
 - Then start the chiller.
 - Adjust the flow of coolant into the heat exchanger for different flow rate like 1.4, 2, 3 lpm.
 - Then took each reading for 10 minutes of interval.
 - Each measurement is repeated at least once.

2.2 Preparation Of Nano fluid

- Preparation of Nano lubricants is the first step in the experimental studies on Nano refrigerants. Nano fluids are not simply liquid solid mixtures. Special requirements are even, stable and durable suspension, negligible agglomeration of particles, and no chemical change of the fluid. Nano fluids can be prepared using single step or two step methods.
- In this experimental work we used single step method.
- Experimental observation shows that the stable dispersion of alumina nanoparticles can be kept for more than 3 days without coagulation or deposition [6].

III. CALCULATION STEPS FOR HEAT TRANSFER COEFFICIENT AND THERMAL CONDUCTIVITY

The heat transfer process is by forced convection. Hence, Nusselt number has been taken as 4.36 for convection process with uniform surface heat flux for circular tubes.

Now by heat transfer equation,

$$mC_p (T7-T8) = h A (T2-T3)$$

From here we can obtain the value of h,

Further the value of k is obtained by Nusselt number equation for flow through internal tubes,

$$Nu = h D_h / k$$

Thus value of k can be obtained from above equation.

3.1 Calculation for COP

COP= refrigerating effect/work required

Refrigerating effect = $m C_p (t_{5i}-t_{5f})$ kJ

Work required = Impulse x 3600/3200 x 600 kW

3.2 Properties

C_p for Water = 4180 J/kg K

C_p for Nano fluid = 880 J/kg K

h – Heat transfer coefficient, W/mK²

m – Mass of fluid, kg

D_h – Hydraulic Diameter

Nu – Nusselt Number

A – Area of heat transfer in heat exchanger = 0.107 m²

k – Thermal conductivity, W/mK

IV. RESULT

In the present experimental study have been considered

Table no.1

FLUID	LP M		T1	T2	T3	T4	T5	T6	T7	T8	T5i - T5f	T8 - T7	IM PULS E	COP	h	K
SIMPLE WATER	1.4	Initi al	39. 4	34. 3	34. 3	29. 7	14	31. 6	33. 6	32. 6	3.3	1.6	83	2.22	97.25	1.15
		Final	31	55	40	5.9	10. 7	32	39. 9	41. 5						
	2	Initi al	37. 1	33. 1	33. 4	29. 3	14. 7	30. 1	37. 9	37. 9	2.9	1.2	88	1.82	171.9 4	2.05
		Final	30. 6	50. 9	41. 8	6.2	11. 8	30. 0	44. 1	45. 3						
	3	Initi al	31. 9	31	31. 6	28. 3	17. 9	28. 4	30. 8	31. 2	3.9	1	90	2.4	238	2.38
		Final	29. 3	44. 7	36. 5	8.3	14. 0	28. 9	30. 8	31. 2						
Al ₂ O ₃ +DISTILL ED WATER (0.25 gm/ltr)	1.4	Initi al	28. 5	21. 9	23. 6	21. 9	16. 4	22. 1	26. 6	26. 6	7.1	3	77	5.11 4	260	3.1
		Final	26. 1	44. 1	33. 1	0.4	9.3	22. 3	31. 9	34. 9						
	2	Initi al	28. 3	21. 8	23. 1	20	12. 1	21. 7	30. 1	30. 2	4.3	1.7	83	2.83	183.9 7	2.19
		Final	25. 4	46. 3	33. 7	0.7	7.8	21. 3	34. 9	36. 6						
	3	Initi al	30. 2	20. 9	22. 3	17. 6	8.2	20. 9	32. 7	32. 7	1.6	0.7	88	1	109.9 1	1.31
		Final	24. 9	46. 5	33. 4	0.2	6.6	20. 6	37 7	37. 7						
Al ₂ O ₃ +DISTILL ED WATER (0.50 gm/ltr)	1.4	Initi al	27. 2	27. 8	29. 8	26. 4	28. 9	28. 9	27. 6	28. 3	12. 3	1.6	73	9.34	303.8 5	3.62 3
		Final	30. 1	40. 3	35	1.4	16. 6	29. 4	33	34. 6						
	2	Initi al	31. 9	30. 6	32. 4	30. 6	27	32	33. 5	33. 5	10. 1	1.2	78	7.18	273.9 8	3.26
		Final	31. 9	45. 4	39. 1	2	16. 9	32. 1	38. 8	40						
	3	Initi al	30	27. 3	29	27. 5	25. 6	28. 8	32. 1	32. 1	16. 3	1	81	11.1 6	359.9 6	4.29 2
		Final	29. 7	43. 7	36. 3	1.6	8.4	26	37. 5	38. 4						
Al ₂ O ₃ +DISTILL ED WATER (0.75 gm/ltr)	1.4	Initi al	29	24	23. 9	19. 9	16	22. 9	31. 5	31. 5	3.7	1.2	70	2.93	130.4 3	1.55
		Final	26. 9	45. 1	35. 4	2.9	12. 3	22. 9	37. 7	38. 9						
	2	Initi al	25. 1	22. 7	24. 1	24. 7	25	23. 3	25. 3	25. 7	8.4	1	72	6.47	195.7	2.33
		Final	26 6	38. 6	30. 9	1.2	16. 6	23	31. 9	32. 9						
	3	Initi al	30	27. 3	29	27. 5	25. 6	28. 8	32. 1	32. 1	17. 2	0.9	80	11.9 2	275.1 8	3.28
		Final	29. 7	43. 7	36. 3	1.6	8.4	26	37. 5	38. 4						
Al ₂ O ₃ +DISTILL ED WATER (1 gm/ltr)	1.4	Initi al	31. 2	30	26. 6	19. 4	14. 7	24. 2	32. 5	32. 5	4.8	1.9	75	3.54	117.4 8	2.11
		Final	26. 5	46. 9	35. 1	6.1	9.9	23. 8	36. 7	38. 6						
	2	Initi al	41	32. 9	32. 9	28. 6	13. 3	29	43. 7	43. 2	3.5	1	80	2.42	117.5 6	1.4
		Final	31. 3	57	43. 6	7.6	9.8	28. 4	46. 1	47. 1						
	3	Initi al	43. 2	35. 8	36. 3	31. 7	13. 9	30	43. 9	43. 9	2.4	0.6	82	1.62	83.97	1.00 1
		Final	33. 2	61. 2	44. 3	9	11. 5	29. 9	46. 7	47. 3						

They are different set of readings are note down for the tabular column are given below the condenser was cooled by Nano fluid and water.

The results of this experimental study can be studied from the following graphs.

1. The following graph shows the relation between thermal conductivity of Nano fluid (0.25 gm/ltr alumina in distilled water) and thermal conductivity of Nano fluid (0.5 gm/ltr alumina in distilled water) at different flow rate.

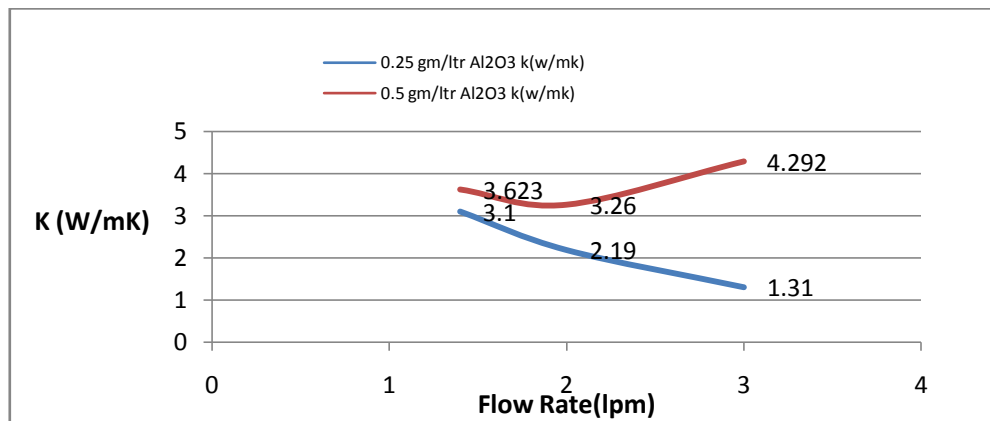


Fig. 2 Thermal conductivity k Vs flow rate (lpm)

The percentage increase in thermal conductivity is 38.45 %.

2. The following graph shows the relation between thermal conductivity of Nano fluid (0.50gm/ltr alumina in distilled water) and thermal conductivity of Nano fluid (0.75 gm/ltr alumina in distilled water) at different flow rate.

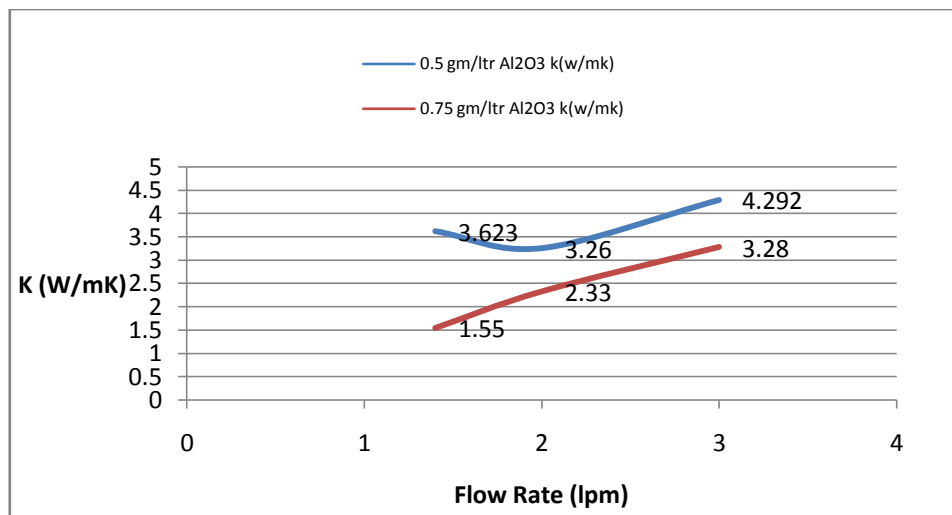


Fig. 3 Thermal conductivity k Vs flow rate in lpm

The percentage increase in thermal conductivity is 30.85 %.

- The following graph shows the relation between thermal conductivity of Nano fluid (0.75 gm/ltr alumina in distilled water) and thermal conductivity of Nano fluid (1 gm/ltr alumina in distilled water) at different flow rate.

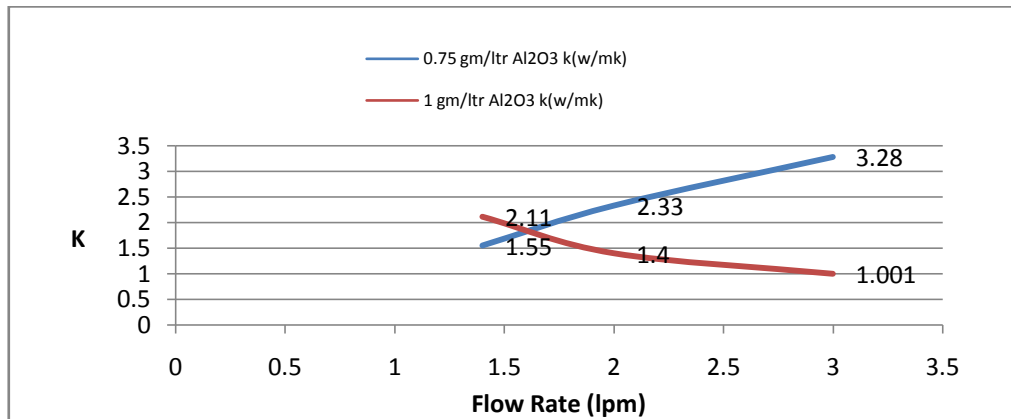


Fig. 4 Thermal conductivity k Vs flow rate in lpm

The percentage increase in thermal conductivity is 55.45 %.

- The following graph shows the relation between thermal conductivity of Nano fluid (0.50gm/ltr alumina in distilled water) and thermal conductivity of simple water at different flow rate.

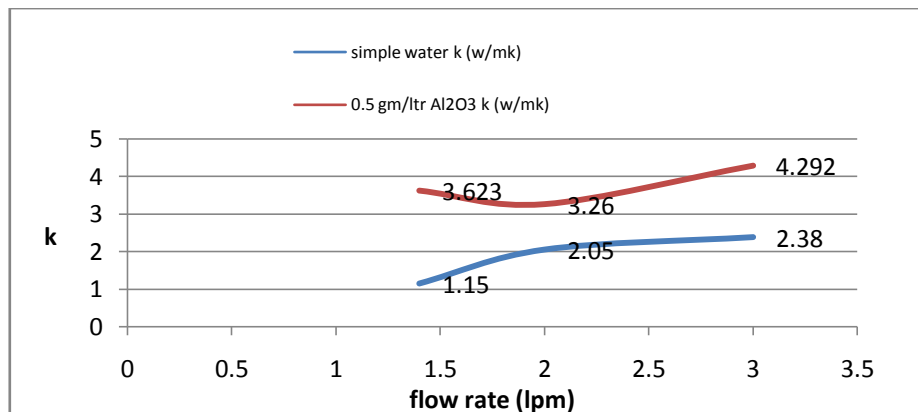


Fig. 5.5 Thermal conductivity k Vs flow rate in lpm

The percentage increase in thermal conductivity is 18.45 %.

5. The following graph shows the relation between thermal conductivity of Nano fluid (0.75 gm/ltr alumina in distilled water) and thermal conductivity of simple water at different flow rate.

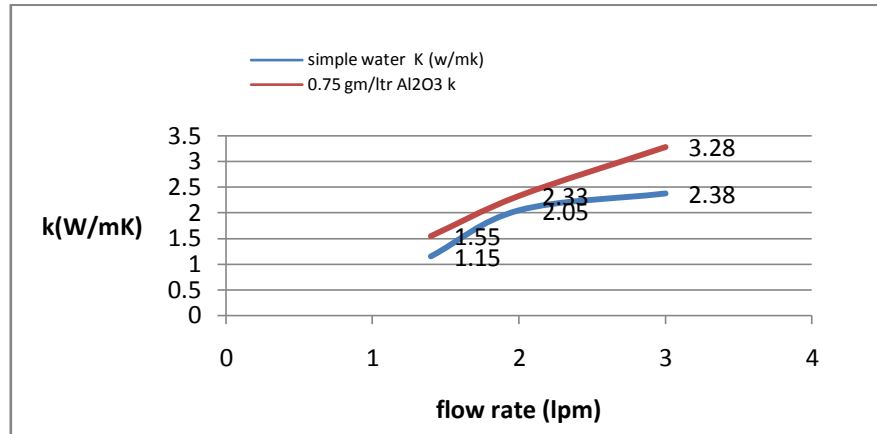


Fig. 6 Thermal conductivity k Vs flow rate in lpm

The percentage increase in thermal conductivity is 37.81 %.

6. The following graph shows the relation between heat transfer coefficient of Nano fluid (0.50 gm/ltr alumina in distilled water) and heat transfer coefficient of Nano fluid (0.75 gm/ltr alumina in distilled water) different flow rate.

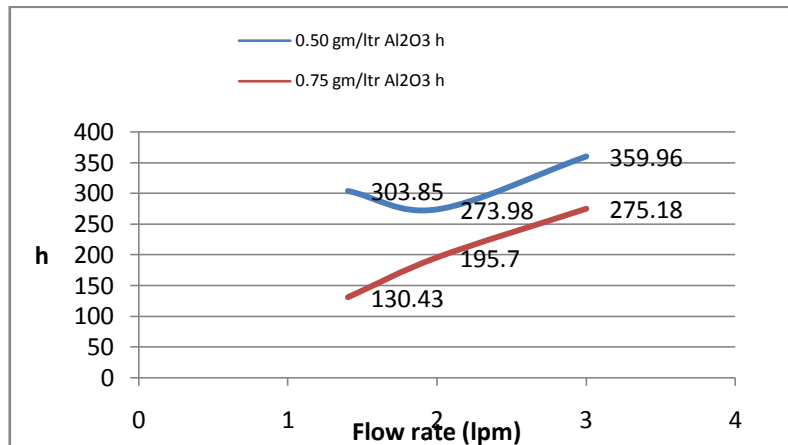


Fig. 7 Heat transfer coefficient h v/s Flow rate in lpm

The percentage increase in heat transfer coefficient is 30.80 %.

7. The following graph shows the relation between heat transfer coefficient of Nano fluid (0.50 gm/ltr alumina in distilled water) and heat transfer coefficient of simple water different flow rate.

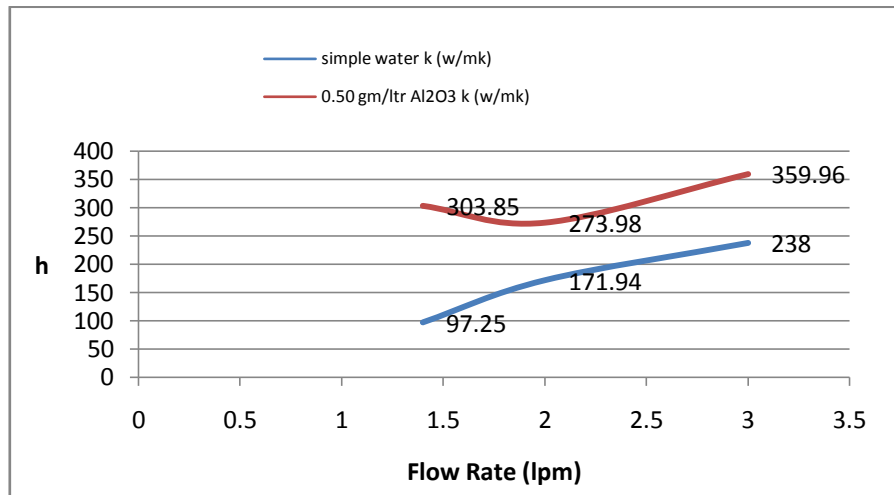


Fig. 8 Heat transfer coefficient h v/s flow rate in lpm

The percentage increase in heat transfer coefficient is 51.24 %.

8. The following graph shows the relation between heat transfer coefficient of Nano fluid (0.75gm/ltr alumina in distilled water) and heat transfer coefficient of simple water different flow rate.

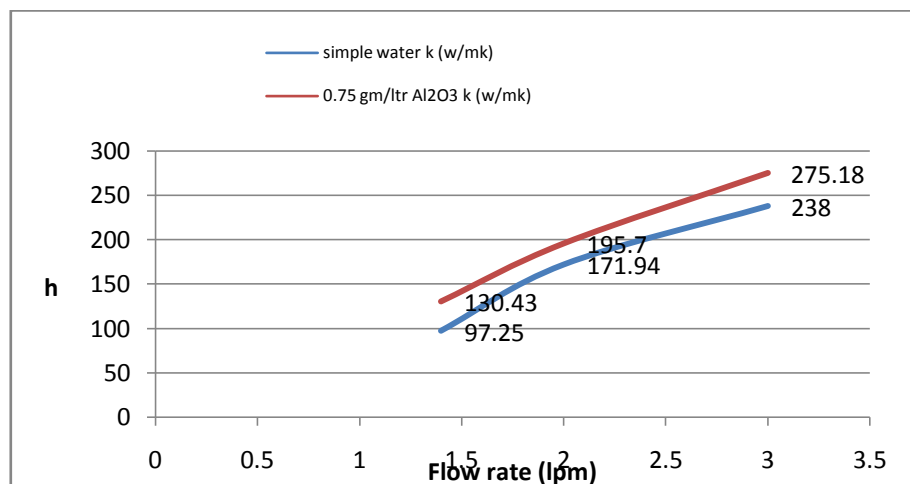


Fig. 9 Heat transfer coefficient h v/s flow rate in lpm

The percentage increase in heat transfer coefficient is 15.62 %.

V. CONCLUSION

The performance test of chiller was conducted by using Nano fluid and water cooled condenser. Al₂O₃ Nano powder 20nm was mixed with distilled water by using sonication process. The aluminium oxide water based Nano fluid was properly stabilized. The experimental result shows the enhancement in heat transfer coefficient and thermal conductivity in the chiller unit by using Nano fluid compared to the base fluid.

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