A Review Over Experimental Investigation Of Aluminium-Water Nano Fluid

Adarsh Kumar P.S , Dr. V.R. Sivakumar , Aswin Mohan

Abstract— **In this paper review over nano fluid research is presented. Various journal papers are studied about different types of nanofliuds and its properties. The base principle behind the nanofluid is that it does have more heat transfer capacity than normal coolants. By adding nanoparticles into a fluid the heat conduction increases because the surface area for heat transfer increases. Since individual nano particles provide individual surface areas. As a group they provide large area for heat transfer. In this research work, we are going to study the heat transfer rate of nano fluid contains water and pure aluminium nano particle. The nano sized pure aluminium particles are added to water to make it a nanofluid. Many journals talk about nanofluids. But little have been studied about the pure metal nano fluids. Most works are based on oxides of various metals added to make the nanofluids. Since pure metals have more conductivity than oxides , they are capable in removing more heat. Hence in heat transfer applications the pure metal nano fluids play an important role. So keeping this in mind it is very important to carryout experimental tests to find the properties of pure metal nanofluid. For this we will manufacture a test setup to study the heat transfer rate by nano fluid with different volume fractions of aluminium. The test setup is such that it is similar to a shell and coil heat exchanger. The inlet temperatures and exit temperatures of the water and nanofluid is noted down. This readings are made used to find out the properties of the nanofluid . Parameters studied are heat transfer rate and volume fraction (5%, 10%, 15% and 20%) of metals and liquid. Relationship between them is evolved through our research.**

Manuscript received June, 2014.

Adarsh Kumar. P.S, *Thermal Engineering, RVS College of Engineering And Technology, Coimbatore, India*

Dr V R Sivakumar, *HOD mechanical , RVS College of Engineering And Technology, Coimbatore, India.*

Aswin Mohan, *Thermal Engineering, RVS College of EngineeringAndTechnologyCoimbatore, India.*

Index Terms—**alluminium, nanofluid, volume fractions, heat transfer rate.**

I. INTRODUCTION

Nano fluid research is increased day by day. Literature shows that research over nano fluid is in heat transfer applications such as condenser, evaporator and refrigeration. Nano fluid is made of liquids and nano particles of metals, metal oxides and non-metals. To improve heat transfer rate in above application, nano particles of metal like aluminium oxide and copper oxide are mixed in liquids water, refrigerants and coolant oils.

It is used in heat transfer application widely. Therefore, research is conducted to study different nano fluid's thermal behaviours. Thermal properties are studied in so many literatures. Few researches are conducted for pure metal nano fluids. Studies are conducted over copper oxide, alumina and silver nano fluids. These research shows that nano fluid's overall performance is poor because, pure metal is not used in study. Thermal property of metal is reduced when they become a compound.

II. LITERATURE REVIEW

Akbar N.S. [1] presented radiation effects on MHD stagnation point flow of nano fluid towards a stretching surface with convective boundary condition. This paper studies the numerical solutions of the steady MHD two dimensional stagnation point flow of an incompressible nano fluid towards a stretching cylinder.. Numerical solutions have been obtained for the velocity, temperature and nano particle fraction profiles. Chan C.Y.[2] presented Enhancement of surface finish using water-miscible nano-cutting fluid in ultra-precision turning. In this paper, the ultra-precision cylindrical turning experiments reveal that the droplet size of the NDCF is a more important factor than viscosity on affecting the surface finish in ultra-precision machining . Dakwar G.R.[3] presented colloidal stability of nano-sized particles in the peritoneal fluid: Towards optimizing drug delivery systems for in traperitoneal therapy. Our data indicate fast aggregation of positively and negatively charged NPs in the peritoneal fluids, which can be prevented by decorating the surface

ISSN: 2278 – 7798

with PEG. Conventional complication of nucleic acids with our Regulated liposome's results, however, in a rapid release of the nucleic acids in the peritoneal fluids, which is not preferred .

Heidary H. [4] presented heat transfer enhancement in a channel with block(s) effect and utilizing Nano-fluid. In this study heat transfer and fluid flow analysis in a channel with blocks attached to bottom wall and utilizing Nano-fluid is numerically studied. The fluid temperature at the channel inlet (Tin) is taken less than that of the walls (Tw). The governing equations are numerically solved in the domain by the control volume approach based on the SIMPLE technique.. Kim S. [5] presented effects of nano-fluid and surfaces with nano structure on the increase of CHF. When nanofluids were used in boiling heat transfer cooling, anomalous increase of CHF was reported. Subsequently, nano particle deposition on the boiling surface was revealed to contribute to CHF enhancement. Lin Y.H. [6] presented effect of silver nano-fluid on pulsating heat pipe thermal performance. In order to study and measure the efficiency, we compare with 20 nm silver nano-fluid at different concentration (100 ppm and 450 ppm) and various filled ratio (20%, 40%, 60%, 80%, respectively), also applying with different heating power (5 W, 15 W, 25 W, 35 W, 45 W, 55 W, 65 W, 75 W, 85 W, respectively). According to the experimental result in the midterm value (i.e. 40%, 60%) of filled ratio shows better. In the majority 60% of efficiency is considered much better. The heat dissipation effect is analogous in sensible heat exchange, 60% has more liquid slugs that will turn and carry more sensible heat, so in 60% of filled ratio, heat dissipation result is better than 40%, and the best filled fluid is 100 ppm in silver nano-fluid.

Pelevi N. [7] presented numerical investigation of the effective thermal conductivity of nano-fluids using the lattice Boltzmann model. The lattice Boltzmann model is proposed for numerical modelling of energy transport inside nano-fluids . Nadeem S. [8] presented non-orthogonal stagnation point flow of a nano non-Newtonian fluid towards a stretching surface with heat transfer. The series solution of steady two-dimensional stagnation point flow of a visco-elastic nano fluid with heat and mass transfer is investigated. The behaviour of the embedded parameters are examined. An analytical technique well known as homogony analysis method (HAM) has been applied to determine the solutions of the governing non-linear ordinary differential equations.. Pham Q.T. [9] presented enhancement of critical heat flux using nano-fluids for in vessel retention. Raveshi M.R. [10] presented experimental investigation of pool boiling heat transfer enhancement of alumina–water–ethylene glycol nanofluids. The results show a critical enhancement of HTC up to 64% for the 0.75% nanoparticles volume concentration. In addition, except for the increment of base fluid properties, the change of the heated surface status is the main factor influences the boiling HTC. More study for evaluation of the effect of nanoparticles on binary mixture pool boiling needs to be done to have a better analysis of this mechanism .

III.EXPERIMENTAL INVESTIGATION

A. Experimental Procedure

Heat transfer rate is calculated from temperature difference between initial and final temperatures of water. Initial temperature is measured at inlet of two liquids at start up of the experiment. Final temperature is measured at outlet. Velocity of water and nano fluid for circulation is constant for all volume fractions of Nano-Fluid (Different volume fractions of Water-Aluminium Nano-Fluid will be prepared for experimentation). Hot water is pumped from reservoir and circulated through shell side. Tube side, nano fluid is pumped.

B. Experimental Condition

- ✓ Velocity of hot water and nano fluid is constant for all volume fractions.
- ✓ Time of circulation is constant for all volume fractions.
- ✓ Temperature is measured at the entry and exit.
- ✓ Velocity of water and nano fluid is controlled by flow control valve.
- ✓ Constant initial temperature is maintained for both clear water and Nano-Fluid for all volume fraction

C. Experimental Setup

Centrifugal pump is used for circulate water, it collects hot water from container and circulates through pipe. Then, water is delivered to cold water tank same for nano fluid. Valve is used to control the flow in the pipes.

ISSN: 2278 – 7798

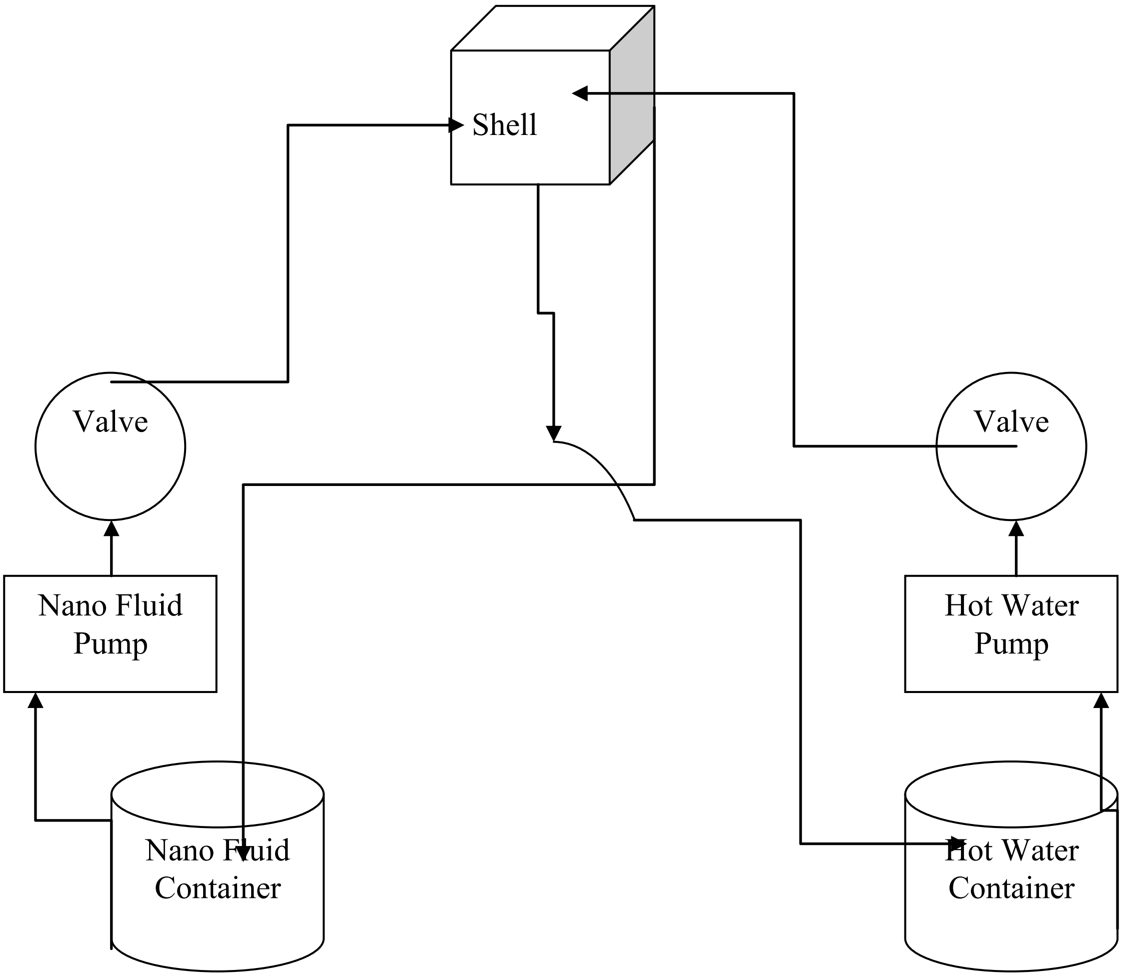

Fig. 1 Experimental Setup Block Diagram

GI pipes with 25.4mm diameter are used to circulate the nano fluid. Coil diameter of tube is 280mm and diameter is19.05mm. Length is 4m and made up of mild steel because it is easy to bend. It is used to measure temperature at entry and exit of both water and nano fluid.

Nano-fluid is prepared by mixing nano particle of size 900nm with water in a proportion. Nano particles are made up of aluminium. Nano-Particle fractions are 5%, 10%, 15% and 20% of volume of water. Electrical heating coil with maximum capacity of 1000W is used to heat water which is to be pumped. Water is heated up to 75°C because there will be chance to boiling nearby heating coil in water if we like to increase temperature more.

IV.EXPERIMENTAL READINGS

Table 4.1inlet and exit temperatures

si no	Volume fraction (%)	Nano fluid inlet temp(0c)	Nano fluid exit temp(0c)	Water inlet temp (0c)	Water outlet temp (0c)
1.	5	26	29	65	58
2.	10	26	29.5	65	56.3
3.	15	26	30.1	65	55
4.	20	26	30	65	53.9

Heat transfer is calculated from following formula:

$$Q = mc[t1 \pm t2]$$

ISSN: 2278 – 7798

Q = Heat rejected from water

m = Mass flow rate of water

c= Specific heat of Water

t1 = Inlet temperature of water

t2 = Outlet temperature of water

Heat absorbed by nano fluid isn't possible to calculate directly because specific heat capacity isn't known. It is calculated from following equation.

Q_{nf} = Heat rejected from water – Heat transferred to atmosphere at shell

Here, water temperature is measured at tube inlet and outlet. Therefore, heat loss at pipe and other components is not considered. But loss at shell to atmosphere during heat transfer between nano fluid and water is considered. So, it is subtracted from heat rejection of water for calculating heat absorbed by nano fluid. This consideration is not necessary for nano fluid because there is no contact between atmosphere.

Heat rejection to atmosphere is calculated as following:

$$Q = UA(T1 - T2)$$

Q = Heat transferred from water to atmosphere

U = Overall heat transfer co-efficient (11.3 $W/m^2.K$ for water-MS-air)

A = Surface area

T_1= Surface temperature of shell

T_2 = Temperature of atmosphere

Table 4.2 Total heat rejection of water

S.No.	Volume Fraction (%)	Mass Flow rate (Kg/s)	Specific heat capacity (J/Kg.°C)	Temp Difference (°C)	Heat Transfer (W)
1	5	0.23	4120	7	6633.2
2	10	0.23	4120	8.7	8244.12
3	15	0.23	4120	10	9476
4	20	0.23	4120	11.1	10518.36

Table 4.3 Heat rejection of water to atmosphere

S.No.	Volume Fraction (%)	Overall Heat transfer co-efficient ($W/m^2.K$)	Surface Area (m^2)	Temp Difference (°C)	Heat Transfer (W)
1	5	11.3	0.288	19	61.83
2	10	11.3	0.288	18.5	60.2064
3	15	11.3	0.288	19	61.83
4	20	11.3	0.288	19.3	62.81

Table 4.4 Heat absorbed by nanofluid

Sl.No.	Volume Fraction (%)	Total Heat Rejection of Water (W)	Heat Rejection of Water to Atmosphere (W)	Heat Transfer of Nano Fluid (W)
1	5	6633.2	61.83	6571.37
2	10	8244.12	60.2064	8183.91
3	15	9476	61.83	9414.17
4	20	10518.36	62.81	10455.55

Table 4.5 Specific heat capacity of nanofliud

S.No.	Volume Fraction (%)	Heat Transfer of Nano Fluid (W)	Mass Flow rate (Kg/s)	Temp Difference (°C)	Specific heat capacity (J/Kg.°C)
1	5	6571.37	0.54	3	4056.40
2	10	8183.91	0.54	3.5	4330.11
3	15	9414.17	0.54	4.1	4358.41
4	20	10455.55	0.54	4	4840.53

ISSN: 2278 – 7798

V. MODEL CALCULATION

A. Total heat rejection of water

$$Q = mc(t1 \pm t2)$$

= 0.23* 4120*7
= 6633.2 W

B. Heat rejection of water to atmosphere

A = Surface area of shell
Length = 420 mm
Breadth = 300 mm
Width = 200 mm
A = 2*(l*w) + (2*(b*w))
= 2*(0.42*0.2) + (2*(0.3*0.2))
= 0.288 m^2

Q = UA ΔT
= 11.3*0.288*19
= 61.83 W

C. Heat absorbed by nano fluid

Heat transfer of nano fluid = total heat rejection of water–heat rejection of water to atmosphere

= 6633.2 - 61.83 = 6571.37 W

D. Specific heat capacity of nano fluid

$$Q = mc(t1 - t2)$$

6571.37 = 0.54*c_p *3
c_p= 4056.4 J/kg^o

VI.RESULTS

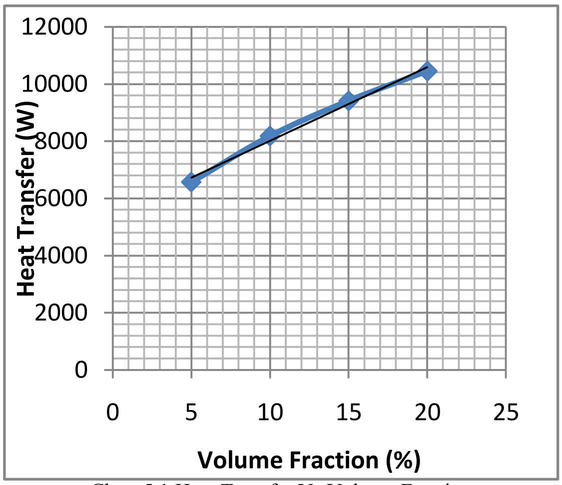

Chart 5.1 Heat Transfer Vs Volume Fraction

Table 5.7 Calculated Heat Transfer And Specific Heat

Sl no	**Volume fraction**	**Heat transfer(W)**	**Specific heat capacity (J/kg°C)**
1	5%	6571.37	4056.40
2	10%	8183.91	4330.11
3	15%	9414.17	4358.41
4	20%	10455.55	4840.53

VII. REMARKS ABOUT THE EXPERIMENTAL READINGS

- As the volume fraction increases the specific heat capacity also increases
- As the volume fraction increases the heat transfer rate also increases

The readings are noted down using the thermocouple. The inlet and outlet temperatures are noted and these values are used to calculate the heat transfer rate . Then the specific heat capacity of the nanofluid is found.

VIII.CONCLUSION

Review over experimental investigation of nano fluid is presented in this paper. Many of literatures have been presented. From this, work is extended to experimental investigation of aluminium-water nano fluid. In this research work, we are going to study the heat transfer rate of nano fluid contains water and pure aluminium nano particle. For this we will manufacture a test setup to study the heat transfer rate by nano fluid with different volume fractions of aluminium. Parameters studied are heat transfer rate and volume fraction (5%, 10%, 15% and 20%) of metals and liquid. Relationship between them is evolved through our research.

REFERENCES

[1].Akbar N.S. (2013) "Radiation effects on MHD stagnation point flow of nano fluid towards a stretching surface with convective boundary condition", Chinese Journal of Aeronautics, Vol 26, pg: 1389-1397.

[2]. Chan C.Y (2013) 'Enhancement of surface finish using water-miscible nano-cutting fluid in ultra-precision turning', International Journal of Machine Tools & Manufacture, Vol 23, pg: 62-70.

ISSN: 2278 – 7798

[3]. Dakwar G.R. (2014) 'Colloidal stability of nano-sized particles in the peritoneal fluid: Towards optimizing drug delivery systems for intra peritoneal therapy', Acta Biomaterialia.

[4]. Heidary H.l (2012) 'Heat transfer enhancement in a channel with block(s) effect and utilizing Nano-fluid", International Journal of Thermal Sciences 57,163-171, Elsevier.

[5]. Kim S. (2010) 'Effects of nano-fluid and surfaces with nano structure on the increase of CHF', Experimental Thermal and Fluid Science 34 487–495, Elsevier.

[6]. Lin Y.H. (2008) 'Effect of silver nano-fluid on pulsating heat pipe thermal performance', Applied Thermal Engineering 28, 1312–1317, Elsevier.

[7]. Pelevi N. (2012) 'Numerical investigation of the effective thermal conductivity of nano-fluids using the lattice Boltzmann model', International Journal of Thermal Sciences, 62, 154-159.

[8]. Nadeem S.l (2013) 'Non-orthogonal stagnation point flow of a nano non-Newtonian fluid towards a stretching surface with heat transfer", International Journal of Heat and Mass Transfer 57, 679–689, Elsevier.

[9]. Pham Q.T. (2012) 'Enhancement of critical heat flux using nano-fluids for In-vessel Retention External Vessel Cooling', Applied Thermal Engineering 35 157-165, Elsevier.

[10].Raveshi M. (2013) 'Experimental investigation of pool boiling heat transfer enhancement of alumina–water–ethylene glycol nano-fluids', Experimental Thermal and Fluid Science 44, 805–814, Elsevier.

