International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 10, October- 2014

Study and Investigation of Heat Transfer Enhancement of Car Radiator by using Nano Fluid – Review

Kiran S Bhusal
Department of Mechanical Engineering ,
Sandip Inst. of Engineering and Management
Nasik ,Maharastra (India)

J. H. Bhangale
Department of mechanical Engineering,
Matoshree COE and RC Nasik
Maharastra india

Abstract **-Heat transfer enhancement in any system is very importance .it is increase the performance and also reduces all their dimensions. in the design of any system space availability is very importance parameter according to this all components and their size and shape selected to make compact design always select the optimize all parameters so there performance doesn't change and output remain same also dimension reduces means material cost and weight of this system reduces .In this paper more focused on the heat transfer enhancement of Car radiator by using nano fluid are discuses in short review. nano fluid is the new generation fluid. it increases the transportation properties of basic fluid in which it added .also some discussion of input parameters such as input temperature ,input flow rate ,concentration of nano fluid and their effect on heat transfers discuses . low thermal conductivity is always the limitation to design energy efficient heat transfer fluid that are required in many industrial application. conventional fluid such as water ,engine oil and ethylene glycol is normally used as a coolant in car radiator .Although various techniques are used to increase the heat transfer rate but low heat transfer rate of this fluid is obstructs the performance and compactness of heat of heat exchanger .use of solid particles as a additives suspended in to base fluid is key idea to improve heat transfer characteristics of conventional fluid**

Key Words –Nano Fluid, Car Radiator, Heat Transfer

I. INTRODUCTION –

There has been more attention toward to increase convective heat transfer rate of nano fluid [1]particle having size less than 100nm added to base fluid to increase thermal conductivity define as a nano fluid [2]in conventional method water, ethylene glycol ,used as coolant in car radiator in these case nano fluid added to base fluid to increase the heat transfer rate [1-9] in case study of nano fluid in car radiator pump for force convection used and the heat transfer rate calculated at different input flow rate [1-4]this rate was compare with nano fluid used in base fluid. Effect of different nano fluid with different concentration calculated and compare with base fluid with actually performed experimental setup readings .[1-10] .different models by using different software are created and compare and verified with actual perform values [1-6] different correlation of thermal conductivity ,viscosity as a function of particle temperature and concentration are used in the different papers [1-3] .Viscosity is also important parameter for performance enhancement and pressure drop is related with the pumping power and viscosity is related with viscosity .as increase the viscosity it increase the pumping power so that the minimization of viscosity is also the critical facture [3-4]. It is observe that viscosity increases when concentration of nano fluid is increases[4].Density is also one of the important properties it is also having direct effect of pumping power and pressure drop. it is not affected by size, shape and additive it is only affected by the concentration of nano fluid[4]

II. IMPORTANT FORMULAS -

According to Newton's low of cooling Nu and Re number can calculated as [1-2,5]

Heat transfer coefficient $Q= h A\Delta T=h A_s (T_b-T_s)$ (1)

Bulk temperature $$T_b = \frac{T_{in}+T_{out}}{2}$$ (2)

Tube wall temperature $$T_s = \frac{T_1+\cdots T_n}{n}$$ (3)

Heat transfer rate $Q=m^* C\Delta T=m^* C\Delta(T\text{-}Tout)$ (4)

Mass flow rate $m^*= \rho V^*$ (5)

Bycomparing (1)and(4)
heat transfer coefficient -

$$h\ exp = \frac{m*C(Tin-Tout)}{As(Tb-Ts)}$$ (6)

Nusselt number $$Nu = \frac{h\ exp\ Dh}{k}$$ (7)

Hydraulic diameter=$$Dh = \frac{4*area}{perimeters}$$ (8)

Reynolds number $$Re\ d = \frac{\rho_{nf}\ Dh\ u}{\mu_{nf}}$$ (9)

III. THERMAL CONDUCTIVITY -

important process in industrial application. heat transfer fluid means working fluid such as ethylene glycol ,water ,and mineral oil play as important role in many industrial application such as power generation, heating and cooling system By enhancing the heat transfer rate the energy consumption is reduces. Heat transfer is and electronics cooling. low thermal conductivity is one of the obstacle in compactness of this system. the material having higher thermal conductivity called as nano particles are added in to this base fluid to increase the heat transfer rate .[28-29]

Table I. Thermal conductivity of different material

Sr. No.	Material	Form	Thermal conductivity W/mk
1	Carbon	Nano tubes	1800-6600
		Diamond	2300
		Graphite	110-190
		Fullerenes film	0.4
2	Metalic solid (Pure)	Silver	429
		Copper	401
		Nickel	237
3	Non Metalic sold	Silicon	148
4	Material Liquid	Aluminum	40
		Sodium	72.3
5	Other s	Water	0.613
		Ethylene Glycol	0.253
		Engine Oil	0.145
		R134a	0.0811

IV. THERMO PHYSICAL PROPERTIES OF NANOFLUID

Heat transfer coefficient of nano particle depend on thermal conductivity of nano fluid, heat capacity of base fluid and nano fluid ,Inlet temperature ,inlet flow rate ,flow pattern, prantal number, Reynolds number, shape and size of nano particle so some important thermo physical properties define as [28-29]

A. *Specific heat of nano fluid –*

Nano fluid specific heat is define as -

$$C_{p_{nf}} = \frac{\emptyset \rho_p C_{P_p} + (1-\emptyset)\rho_{bf} C_{p_{bf}}}{\rho_{nf}}$$

B. *Density –*

Nano fluid density is the ratio of nano fluid and base fluid density -

$$\rho_{nf} = \emptyset \rho_p + (1-\emptyset)\rho_{bf}$$

C. *Specific heat -*

Specific heat of nano fluid is define as follows -

$$Cp_{nf} = \frac{\emptyset \rho_p Cp_p + (1-\emptyset)\rho_{bf} Cp_{bf}}{\rho_{nf}}$$

D. *Viscosity -*

Accurate model for viscosity calculation practically nano available but in many cases use the following correlation to calculate the Viscosity at room temperature

$$\mu_{nf} = \mu_{bf}(1 + 39.11\phi + 533.9\emptyset^2)$$

E. *Thermal conductivity -*

Thermal conductivity of nano fluid for Al2O3+water is developed by

$$\frac{K_{nf}}{K_{bf}} = Re_{nf}^{\,0.175}\emptyset^{0.5}\left(\frac{K_b}{K_{bf}}\right)^{0.2324}$$

V. EXPERIMENTAL REVIEW ON HEAT EXCHANGER -

Experimental Review on nano fluid used in different heat exchanger at different concentration and size and at different base fluid (Thermal conductivity of Al2O3- based nano fluids) –
from following table it is show that increase in fraction of volume of nano fluid increase the thermal conductivity .decreasing nano particle size and shape also influence the thermal conductivity the following table shows the summary of Al2o3 base fluid

Table II. Effect of Concentration and size on Enhancement Ratio

Author	Base fluid	Concentration	Particle size	Enhancement ratio
Masuda et al.	Water(31.85°c)	1.3 to 4.3	13	1.10 to 1.32
	Water(46.85 °c)			1.10 to 1.29
	Water(66.85 °c)			1.09 to 1.26
Lee et al.	Water	1 to 4.5	38.4	1.03 to 1.10
	Ethylene	1 to 5		1.03 to 1.18
Wang et al	Water	3.0to 5.5	28	1.11 to 1.16
	Ethylene Glycol	5.0 to 8.0		1.25 to 1.41
	Engine oil	2.24 to 7.70		1.05 to 1.30
	Pump oil	5.00to 7.10		1.13 to 1.20
Eastman et al.	Ethylene Glycol	1.00 to 5.00	35	
Xie et al.	Water	1.8 to 5.00	60.4	1.07 to 1.21
	Ethylene Glycol	1.8 to 5.00	15	1.06 to 1.17
	Ethylene Glycol	1.8 to 5.00	26	1.06 to 1.18
	Ethylene Glycol	1.8 to 5.00	60.4	1.10 to 1.30
	Ethylene Glycol	1.8 to 5.00	302	1.08 to 1.25
	Pump Oil	5.00	60.4	1.39
Xie et al	Water	50.00	60.4	1.39
	Ethylene Glycol	5.00		1.21
	Pump Oil	5.00		1.29
	Glycerol	5.00		1.38
Das et al.	Water(21°c)	1.00 to 4.00	38.4	1.02 to 1.09
	Water(36 °c)			
	Water(51 °c)			
Wen	Water +sodium	0.19 to 1.59	42	1.01 to 1.09

&Ding	DBS			
Li & Petorson	Water(27.5°c)	2.00 to 10.00	36	1.08 to 1.11
	Water(32.5 °c)			1.15 to 1.22
	Water(34.7 °c)			1.18 to 1.29
Beck et al	EG (27°c)	1 to 4	20	1.015 to 1.14
Hwang et al.	Water	0.3 to 1.0	48	1.013 to 1.04
Timofeeva et al.	Water EG	5.0	11	1.08
		5.0	20	1.07
		5.0	40	1.10
		5.0	All sizes	1.13
Lee et al.	Water	0.01 to 03	35	1.005 to 1.02
Murshed et al	Water	1	80	1.03 to 1.12
	EG	0.5	150	1.02 to 1.10
	CTAB	1	80	1.03 to 1.09
			80	1.06 to 1.12
Choi et al	Transformar oil+Oleic acid	0.5 to 4.0	13	1.05 to 1.20
Oh et al	Water	1 to 4.0	45	
	EG	1 to 4.0	45	1.019 to 1.097
Kole et al	Car engine coolant	3.5	50	

VI. EXPERIMENTAL REVIEW ON CAR RADIATOR -

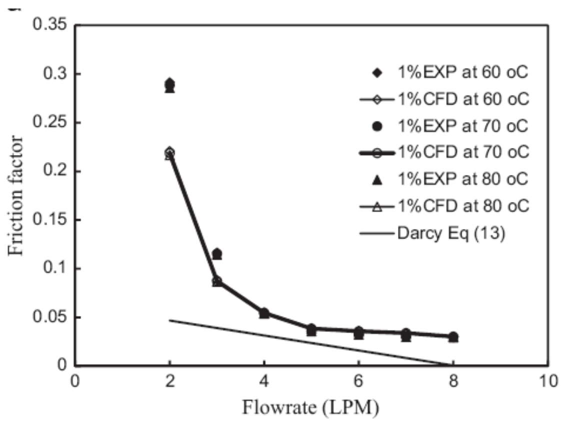
Table III. 6Experimental Review on nano fluid used in Car radiator at different concentration ,different inlet temperature ,&different flow rate

Ref .No.	Nano particles	Working conditions	Conclusion/result
1	SiO_2	Four different concentrations1to2. 5%	If Concentration increases then Heat transfer rate increases
		Flow rate 2to8lpm	If flow rate increases heat transfer rate increases
		Inlet temperature	Nusselt number increases
		Nano particles TiO_2 , SiO2	Heat transfer rate (SiO_2) is higher than(TiO_2)
2	TiO_2 SiO_2	Concentration(1to 2 %)	If Concentration increases then Heat transfer rate increases
		Volume flow rate(1to 2%)	If flow rate increases heat transfer rate increases
		Inlet temprature60to80° C	Nusselt number increases
3	Al_2O_3 TiO_2	Nano particles Al_2O_3 ,TiO_2/water	Heat dissipation of TiO_2 is higher than Al2O3
		Concentration(1to 2 %)	If concentration increases heat dissipation rate increases
		Volume flow rate(1to 2%)	If flow rate increases heat dissipation rate increases
		Ethylene glycol /water	Heat dissipation rate is less than nano fluid
4	Al_2O_3 EG	Effect of volume concentration on -	
		a)Thermal conductivity	If concentration increases then thermal con. increases
		b)Viscosity	If concentration increases then viscocity increases
		c)density	If concentration increases then density increases
		d)Specific heat	If concentration increases then Specific heat decreases
5	CuO	Concentration (0to0.4%)	If Concentration increases then Heat transfer rate increases
		Inlet temperature (60to80° C)	If inlet temperature increases heat transfer rate decreases
		Volume flow rate	If flow rate increases heat transfer rate increases
6	CuO Fe_2O_3	Nanoparticles CuO ,Fe_2O_3	Fe_2O_3 Has high heat transfer capacity
		Concentration(0.15 to 0.65 %)	If Concentration increases then Heat transfer rate increase
		Inlet temperature (50to80° C)	If inlet temperature increases heat transfer rate decreases
		Air velocity	If air velocity increases then Heat transfer rate increase
		Flow rate	If flow rate increases then Heat transfer rate increase
7)	Al_2O_3	Concentration	If Concentration increases then Heat transfer rate increases
		Flow rate	If flow rate increases then Heat transfer rate increase
		Fluid inlet temperature	If inlet temperature increases heat transfer rate decreases
8	Al_2O_3 EG and Water separately	Al_2O_3+EG+Water	Heat transfer rate increases
		Concentration(0.1 to 1%)	If Concentration increases then Heat transfer rate increases
		Flow rate	If flow rate increases then Heat transfer rate increase
9	Al_2O_3 CuO	Effect of concentration on Concentration	**(Numerical study)**
		Al_2O_3 (10%)	Heat transfer rate increases 94%
		CuO (9%)	Heat transfer rate increases 89%
		Skin friction coe.	Skin friction coee. increases with increasing concentration
		Pumping power reqd	82% lower Al_2O_3 ,77% lower inCuO
10	Copper	Concentration (0 to 2%)	H.T .rate increases
		Frontal area	Reduces 18.7%

VII. EXPERIMENTAL INVESTIGATION -

A. Friction Factor and Inlet temperature -

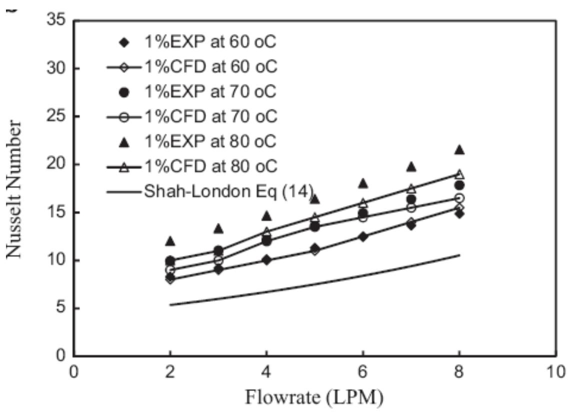
Adnan M.Hussein(2014) investigate the effect of inlet tempreture on friction factor , at diffrant flow rate and deferent inlet temperature the friction facture shown in fig. I it shows that if there is increasing the volume flow rate then friction facture factor decreases and also decreases with increasing inlet temperature [1]



FigureI. Inlet Temperature effect on friction factor

B. Nusselt number at different inlet temperature-

Adnan M.Hussein(2014) investigate the effect of inlet temperature and flow rate ,it shows the Nusselt Number at different inlet temperature and different Reynolds number Fig.2 shows that the if increasing the volume flow rate and increasing the inlet temperature the Nusselt number increases [1]

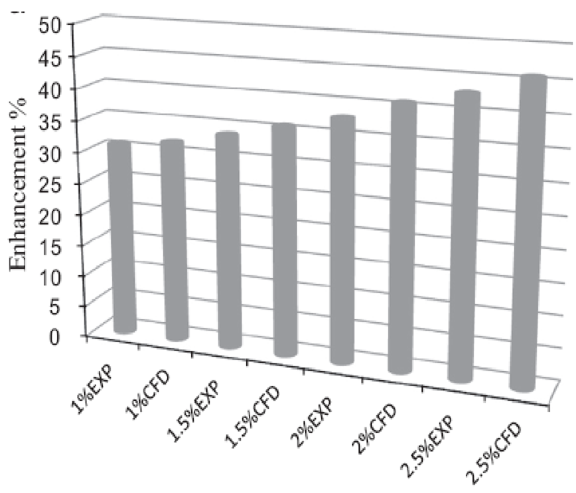


FigureII. Nusselt number deviation because of inlet temperature .

VIII. ENHANSMENT BY USING VOLUME CONCENTRATION AND INLET TEMPRETURE

A. By using Volume concentration -

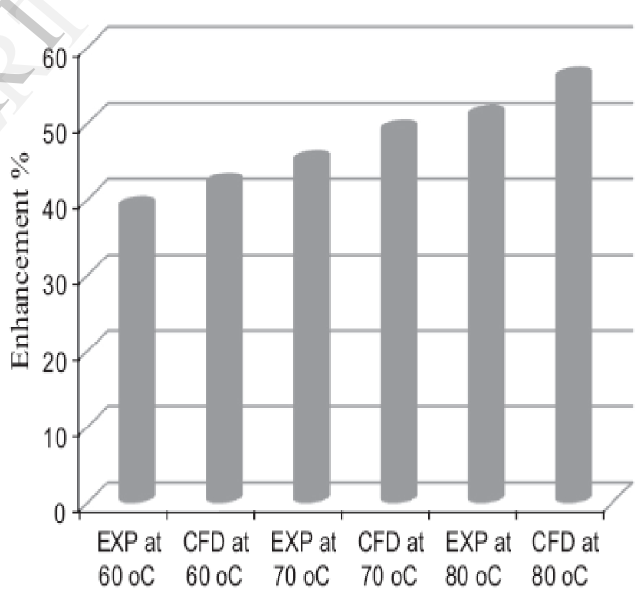
Adnan M.Hussein (2014)) investigate the effect of Volume concentration and heat transfer enhancement . Fig. III shows that heat transfer rate of car radiator is depend on nano fluid volume concentration .it is shows that if increasing the volume concentration of nano fluid the heat transfer enhancement rate also increases heat transfer enhancement increases from 31% to 46 % when volume concentration increases from 1% to 2.5%[1]



FigureIII. Nano fluid volume concentration effect on heat transfer enhancement

B. By using inlet temperature-

Adnan M.Hussein (2014)) investigate the effect of inlet temperature on Enhancement . Fig IV shows that heat transfer rate of car radiator is depend on nano fluid inlet temperature of car radiator it is shows that the heat transfer enhancement from 39% to56% from if increase the temperature from 60 to 80^{O}C[1]

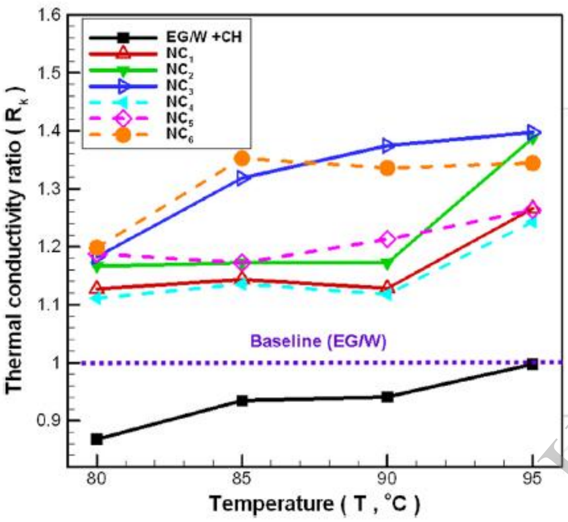


FigureIV. The effect of nano fluid inlet temperature.

IX. EFFECT OF TEMPERATURE AND CONCENTRATION ON THERMAL CONDUCTIVITY ,SPECIFIC HEAT VISCOSITY REYNOLDS NUMBER

A Effect of Temperature and concentration on Thermal conductivity -

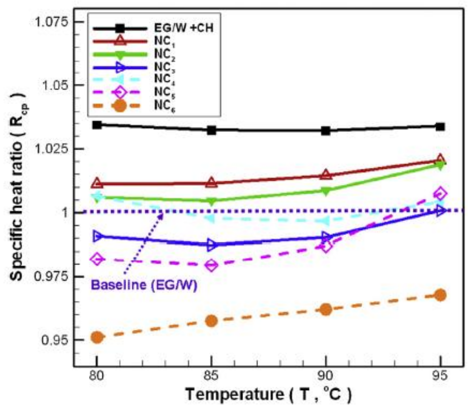
Hwa-Ming Nieh (2014) Investigate the effect of Temperature and concentration on Thermal conductivity Fig. V Shows the effect of volume concentration and inlet temperature on thermal conductivity .in this case NC_1 NC_2 NC_3 NC_4 NC_5 NC_6 are the nano coolant at different concentration like 26.6 % ,38.7% , 39.7 % ,24.3% , 26.3 % ,35.2% respectively and thermal conductivity increases from inlet temperature rang 80°C to 95°C and concentration NC1 To NC6[3]



FigureV. Thermal conductivity ratio of samples at various temperatures and concentrations.

B. *Effect of Temperature and concentration on Specific heat*

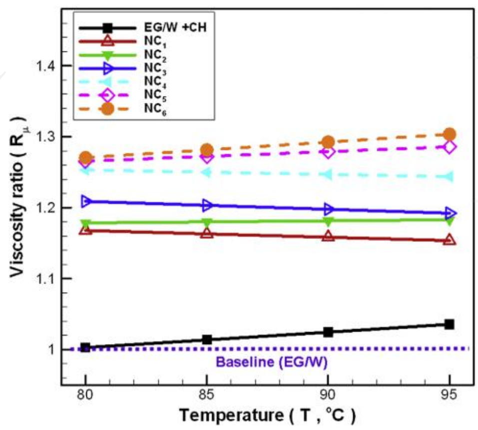
Hwa-Ming Nieh (2014) Investigate the effect of Temperature and concentration on Specific heat Fig.VI shows that effect of various temperature on specific heat over a rang of 80-90°Cfrom result it is shows that specific heat of Al2O3 NC is higher than the TiO2NCand increasing the temperature of sample the specific heat also increases but if increasing the concentration the specific heat also decreases [3]



FigureVI. Specific heat of samples at various temperatures and concentrations

C . *Effect of Temperature and concentration on Viscosity -*

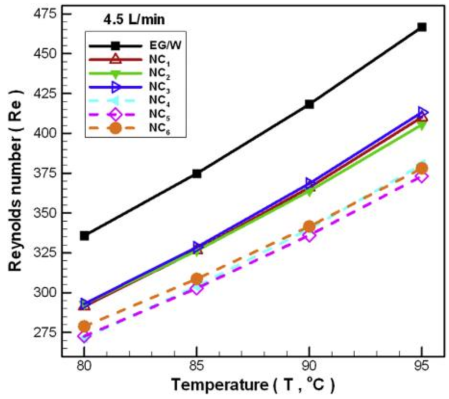
Hwa-Ming Nieh (2014) Investigate the effect of Temperature and concentration on Viscosity Fig.VII shows the viscosity increases with increasing the concentration and it is found that viscosity of TiO_2 NC is higher than Al2O3 NC [3]



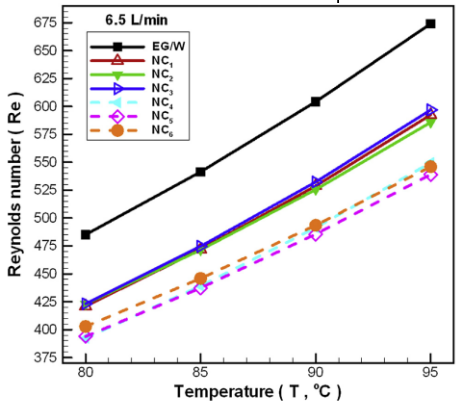
FigureVII. Viscosity of samples at various temperatures and concentrations.

D .Effect of Temperature and concentration on Reynolds number -

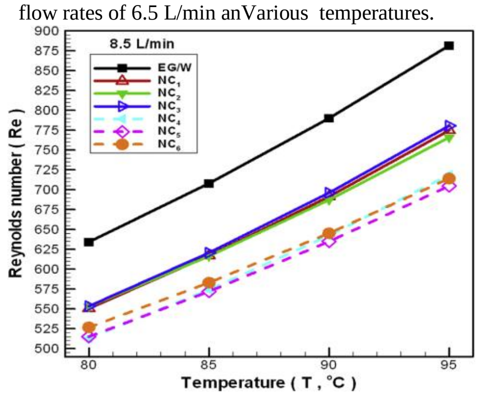
Hwa-Ming Nieh (2014) Investigate the effect of Temperature and concentration on Reynolds number Fig .VIII ,IX,X shows the effect of various concentration ,temperature and volumetric flow rate at 4.5 ,6.5,8.5 L/min respectively on Reynolds number .it is shows that adding the nano particle in to base fluid reduce the base fluid Re ,and adding Tio2 influence the more Re number as compare to Al2O3 [3]



FigureVIII. Reynolds numbers of the samples at volumetric flow rates of 4.5 L/min anVarious temperatures.



FigureIX. Reynolds numbers of the samples at volumetric flow rates of 6.5 L/min anVarious temperatures.

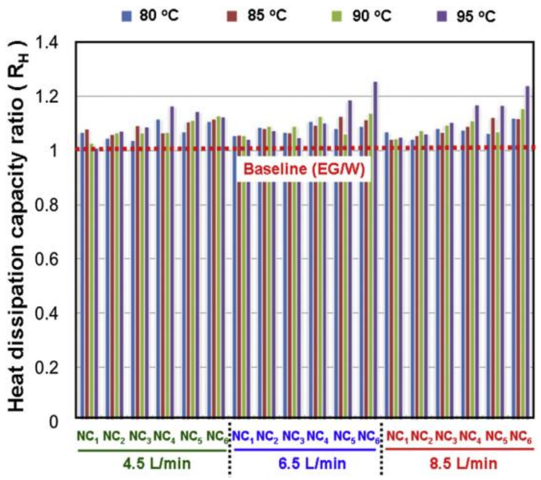


FigureX. Reynolds numbers of the samples at volumetric flow rates of 8.5 L/min and various temperatures

X. EFFECT OF NC CONCENTRATION ,TEMPERATURE, AND FLOW RATE ON HEAT DISSIPATION PRESSURE DROP, PUMPING POWER ,AND EFFICIENCY FACTOR

A. Effect of NC Concentration, temperature, and flow rate on Heat dissipation -

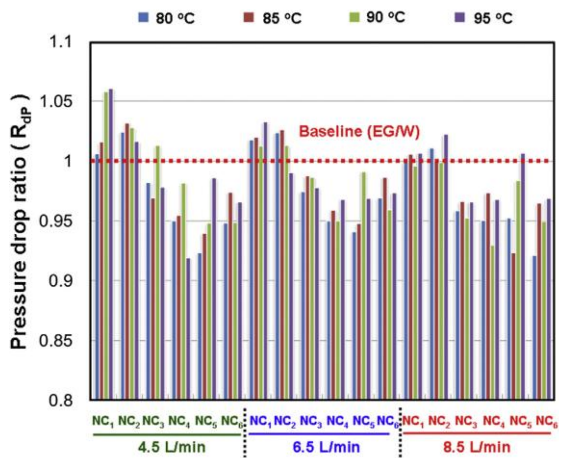
Hwa-Ming Nieh (2014) Investigate the effect of NC Concentration, temperature, and flow rate on Heat dissipation Fig.XI shows the heat capacity ratio affected by different NC concentration, heating temperature, volume flow rate. the result shows that nano particle concentration and inlet temperature not having any significance influence effect on heat dissipation capacity but high nano particle concentration and high flow rate influence the and enhance the heat dissipation capacity [3]



FigureI. Effect of NC Concentration, temperature, and flow rate on Heat dissipation.

B. Effect of NC Concentration, temperature, and flow rate on Pressure drop-

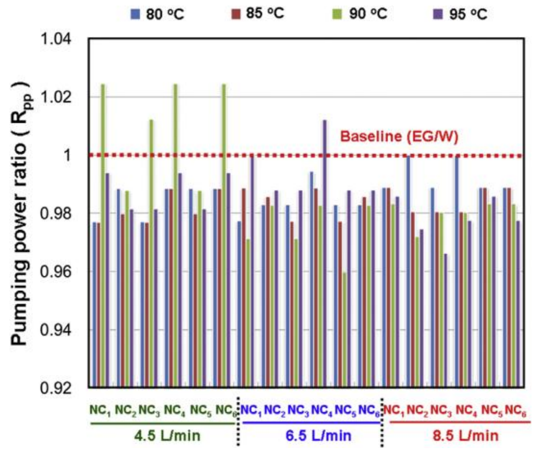
Hwa-Ming Nieh (2014) Investigate the effect of NC Concentration,temperature, and flow rate on Pressure drop Fig. XII shows the effect on pressure drop of the Different NC Concentration ,heating temperature ,,volumetric flow rate .Al2O3 and TiO2 shows the different result .in case of Al2O3 the pressure drop decreases when concentration increases and in case TiO2 concentration shows irregular status [3]



FigureII. . Effect of NC Concentration, temperature, and flow rate on Pressure drop.

C .Effect of NC Concentration, temperature, and flow rate pumping power

Hwa-Ming Nieh (2014) Investigate the effect of of NC Concentration, temperature, and flow rate pumping power .Fig. XIII shows the effect on pumping power because of the different nano particle concentration, heating temperature and volumetric flow rate .changing pumping power in case of both nano coolant is very small the pressure drop and pumping power shows the non linear relation because of fluid mechanica characteristic of pump [3]



FigureIII. C Effect of NC Concentration ,temperature, and flow rate pumping power

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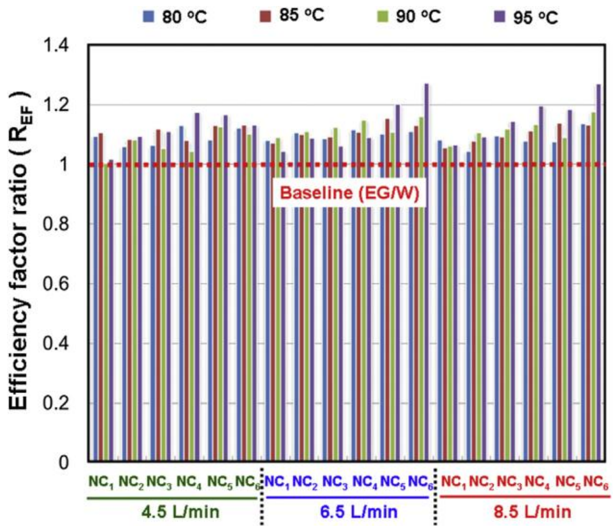
D *Effect of NC Concentration, temperature, and flow rate Efficiency factor -*

Hwa-Ming Nieh (2014) Investigate the effect of NC Concentration, temperature, and flow rate Efficiency factor. Fig.XIV shows the effect on the EF ratio of the NC concentration,heating temperature and volumetric flow rate fig clearly shows that the EF of NC is higher than the base fluid and EF of Al_2O_3 NC is lower than the that of TiO_2 NC .the Al_2O_3 nano fluid increases the EF by 14.4%at 95 ^{O}C at 8.5volume flow rate and TiO_2 by 27.2% at 95^{o}C at 6.5 L/min with respect to EG/W [3]



FigureIV. Effect of NC Concentration ,temperature, and flow rate Efficiency factor.

Conclusion –

This paper present the recent review on heat transfer enhancement of Car radiator by using nano fluid .heat transfer coefficient of nano fluid is always greeter than base fluid like water or ethylene glycol and performance of nano fluid is affected by thermo physical properties like viscosity, density specific heat and other parameters like flow rate ,concentration and inlet temperature .heat transfer coefficient is increses with increasing concentration .inlet temperature and flow rate .

Nomenclature

C	heat capacity rate, W/C
Cp	specific heat J/kg C
h	heat transfer coefficient, W/m2 C
k	thermal conductivity, W/m C
m	mass flow rate, Kg/sec
Nu	Nusselt number
Q	heat transfer rates, KW
Re	Reynolds number
U	overall heat transfer coefficient W/ C
ρ	density, kg/m3
µ	dynamic viscosity, Kg/m s

Subscripts

a	air side
c	coolant side
bf	base fluid
nf	nano fluid
p	nano particle

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