



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 5, May 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijrset@gmail.com

www.ijrset.com

Experimental and CFD Analysis of Car Radiator with Different Concentrations of Copper Oxide Nanofluid

Pratiksha Shinde¹, Rushikesh Davane², Akanksha Saravade³, Rohan Nannware⁴,

Prof. Sagar Wangdare⁵

UG Student, Department of Mechanical Engineering, D. Y. Patil College of Engineering, Akurdi, India¹

UG Student, Department of Mechanical Engineering, D. Y. Patil College of Engineering, Akurdi, India²

UG Student, Department of Mechanical Engineering, D. Y. Patil College of Engineering, Akurdi, India³

UG Student, Department of Mechanical Engineering, D. Y. Patil College of Engineering, Akurdi, India⁴

Ass. Professor, Department of Mechanical Engineering, D. Y. Patil College of Engineering, Akurdi, India⁵

ABSTRACT: The cooling medium used in radiators today is water or a water-like substance. However, the thermal conductivity of these corresponding cooling media is lower, which results in less heat being dissipated from cooling systems. For greater performance, the fluids used as coolant must be well chosen. This demonstrates the necessity of the locomotive cooling system having a different cooling medium. In an effort to get better results, researchers are testing Nano fluid as a cooling medium in locomotive cooling systems. When combined with base fluid, metal-related nanoparticles should demonstrate better thermal conductivity compared to the base fluid since their thermal conductivity is higher than that of current cooling mediums. Nano fluid can be used to cool the radiators of automobiles. This study uses experimental methods to determine how well radiator performance is evaluated at various volume flow rates. CATIA V5R20 is used to create a 3D model of the radiator. For this investigation, a variety of fluids are used as cooling fluids, including pure water, ethylene glycol with a 1% concentration of Copper Oxide Nano Fluids, ethylene glycol with a 2% concentration of Copper Oxide Nano Fluids, and ethylene glycol with a 3% concentration of Copper Oxide Nano Fluids.

KEYWORDS: Copper Oxide, Ethylene glycol, Radiator, Nanofluid.

I. INTRODUCTION

Energy conservation is a significant problem for the future and a pressing concern in the twenty-first century. Engineers and scientists are working hard to find a solution to this issue. Enhancing heat transfer efficiency and extending equipment lifespan are all benefits of improving heat transfer in industrial devices like heating and cooling systems. Efficiency in energy consumption, energy conversion, conservation, and recovery can all help save energy. By cutting down on heat exchange time and raising system efficiency overall, efforts have been undertaken to increase heat exchanger efficiency. Fins have been a popular method of increasing heat transfer area, however this method has limitations because it increases the weight and volume of the heat exchangers. Another technique involves improving the thermal characteristics of heat transfer fluids, which can enhance convective heat transfer. This can be achieved by adding additives to modify the fluid's properties, and recent advancements in nanotechnology have opened up possibilities in this area. The concept of "Nano fluids," which combine conventional fluids with solid nanoparticles, was introduced to improve heat transfer characteristics. Nano fluids offer advantages such as high thermal conductivity and stability. Nano fluids have shown promise in heat transfer enhancement for heat exchangers, and many researchers have utilized them for this purpose. Heat exchangers are designed to maximize surface area while minimizing fluid flow resistance. Fins or corrugations can be added to increase surface area and induce turbulence or channel fluid flow, further improving performance.

II. RELATED WORK

1. R. Prasanna Shankara et al.: In this paper author discussed about experimental study of graphene oxide nanoparticles of size 20 to 80 nanometer is used for different concentrations of nanofluids. This study examined the heat transfer properties of nanofluids made up of various ratios of Graphene Oxide, Deionized Water, and EG. Author uses 0.1% GO based EG mixture employed at coolant inlet temperature of 90 C and the flow rate varies from 180 to 420 LPH. Author use different EG to DW like 60:40, 30:70, 20:80. A mixture made of 60% EG (ethylene glycol) and 40% DW (deionized water), with the addition of 0.1% GO (graphene oxide), was found to be quite stable. This mixture had a higher zeta potential (an indicator of stability) of -47.48 mV compared to two other mixtures. In simple terms, this means that the mixture with GO is less likely to separate and is more stable than the other mixtures tested. Using nanofluids can improve the way heat is transferred, which can make radiators smaller and lighter without sacrificing their performance. This can lead to cars that use less fuel, while still delivering the same amount of power. It also makes it easier to design cars in a more environmentally friendly way.
2. Kader et al.: In this project, author is using nanofluid that contains very tiny particles of copper oxide mixed with either pure water or a liquid called ethylene glycol. They are testing three different concentrations of the nanofluid to see how well it works as a coolant in a car radiator. They want to see if adding the nanofluid to the radiator can help keep the car engine cool more efficiently. They investigate laminar flow convective heat transfer of CuO ethylene under constant wall temperature with 0.1 to 1% volume of nanoparticles for RE varying 700 to 2050.
3. M. Allen Zennifer et al.: The researchers made a liquid by adding tiny particles of cupric oxide to ethylene glycol using sound waves. This new liquid is called a nanofluid, and it can transfer heat better than regular ethylene glycol. It also flows more easily, which can save energy when used in machines. The researchers found that the nanofluid with 1% cupric oxide had 13% less thickness and 11% more heat transfer than regular ethylene glycol at temperatures between 30 to 50 degrees Celsius. This means that the new liquid can help machines run more efficiently and save energy. The researchers believe that using this new nanofluid as a coolant is a promising way to manage energy in machines.
4. Sumit G. Wani et al.: According to the researcher's findings, adding MgO nanoparticles in water significantly increased the rate of heat transfer. The findings show that a rise in the volume percentage of these nanoparticles can result in a substantial increase in heat transfer rate, ranging from 39.48% to 70.45%. In addition, the convective heat transfer coefficient, Reynolds number, and Nusselt number were also found to increase with the increasing particle concentration. Furthermore, it has been observed that as the concentration of particles in the fluid increased, the density, thermal conductivity, and dynamic viscosity of the fluid also increased. However, the specific heat capacity decreased. These observations provide valuable insights into the potential applications of using MgO nanoparticles as a means of enhancing the cooling performance of liquids.

III. METHODOLOGY

1. Literature review of the automotive radiator with use of nanofluids as their coolant
2. Fabrication of Experimental Setup and preparation of nanofluid.
3. Experimental trials on the Radiator with nanofluid.
4. Numerical simulation using Ansys FLUENT.
5. Results and discussion of the Experimental trials and their comparative study.

IV. EXPERIMENTAL RESULTS

Rough Hand-drawn drawings on CATIA V5 were revised until the following drawings where finalized.

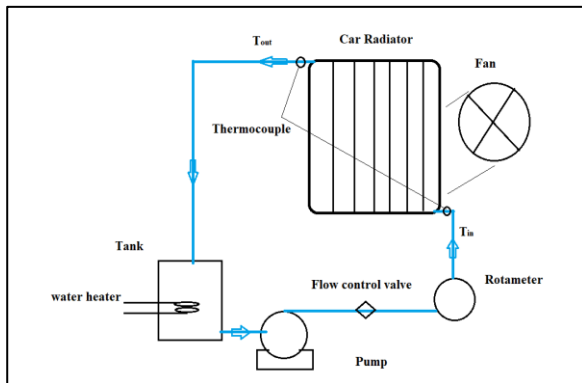


Figure 1: System Layout

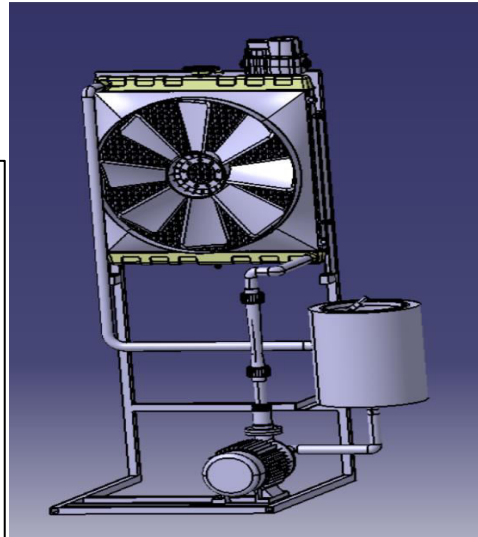


Figure 2: Experimental Setup

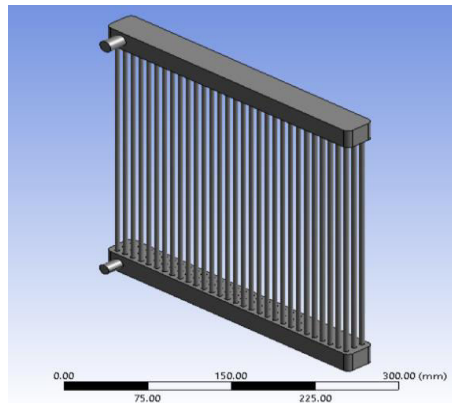
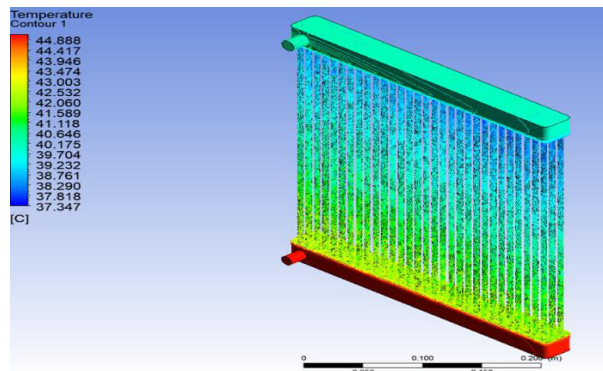


Figure 3: CAD Model of Radiator

TEMPERATURE CONTOUR RESULTS IN ANSYS FLUENT:

For 1% CuO ethylene glycol based Nanofluid

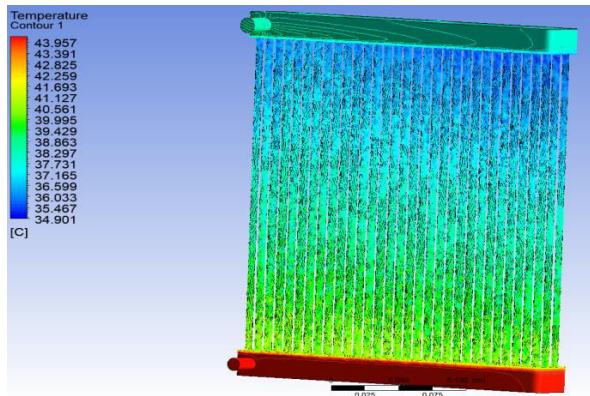
150 LPH





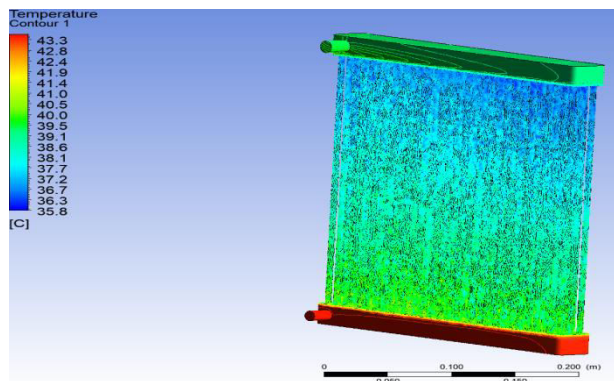
The contour shows the temperature results for 1% CuO ethylene based nanofluid at 150 LPH. The outlet temperature of the 1% CuO ethylene glycol based nanofluid is 40.6 ° C. The temperature difference obtained is 4.5 ° C.

200 LPH



The contour shows the temperature results for 1% CuO ethylene based nanofluid at 200 LPH. The outlet temperature of the 1% CuO ethylene glycol based nanofluid is 39.89 ° C. The temperature difference obtained is 4.30 ° C.

250 LPH



The contour shows the temperature results for 1% CuO ethylene based nanofluid at 250 LPH. The outlet temperature of the 1% CuO ethylene glycol based nanofluid is 39.782 ° C. The temperature difference obtained is 3.61 ° C.

SAMPLE CALCULATIONS

FORMULAE

Thermophysical properties

The Thermophysical properties of the nanofluids vary with temperature. The physical and thermal properties of EG based CuO nanofluids such as viscosity (μ_{nf}), thermal conductivity (k_{nf}), specific heat capacity (C_{pnf}) and density (ρ_{nf}) are shown in Table 8.1.

Specific heat of Nanofluid ($C_{p,nf}$): It is defined as the quantity of heat per unit mass of a material to elevate the temperature by one degree centigrade. In order to determine the specific heat of nanofluids, the following expression is used:

$$\rho_{nf} C_{(p,nf)} = \phi_{np} \rho_{np} C_{(p,np)} + (1 - C_{np}) \rho_{bf} C_{(p,bf)} \quad (5.1)$$

where ρ_{nf} stands for density of nanofluid, C_{pnf} is specific heat of nanofluid, ϕ_{np} is the percentage of weight fraction of nanoparticle, and bf is base fluid.



Density of nanofluid: Density of the nanofluid is mathematically determined by the following equation :

$$\rho_{(np)} = \phi_{np} \rho_{np} + (1 - \phi_{np}) \rho_{bf} \quad (5.2)$$

Viscosity for nanofluids was calculated by the

Following equation,

$$\mu_{np} = \mu_{bf} (1 + 7.3 + 173 \psi^{2.1}) \quad (5.3)$$

Thermal Conductivity (knf):

Thermal conductivity depends on the factors like surface area, temperature, shape of the nanoparticle, and volume fraction. The mathematical equation to calculate the thermal conductivity of a nanofluids given in Eq. (4). Stability of

$$k_{nf} = (k_{np} + 2k_{bf} + 2(k_{np} - k_{bf})) / (k_{np} + 2k_{bf} - (k_{np} - k_{bf})) k_{bf} \quad (5.4)$$

Different relations were used to calculate heat transfer parameters for the nanofluid in the automobile radiator. The heat transfer rate was calculated using Eq

$$Q = m C_P (T_{in} - T_{out}) \quad (5.5)$$

The convective heat transfer coefficient on coolant side h was calculated using Eq

$$h = Q / nA (T_b - T_w) \quad (5.6)$$

$$T_b = ((T_{in} + T_{out}) / 2) \quad (5.7)$$

$$Nu = h x D_h / K_{nf} \quad (5.8)$$

Where Nu is Nusselt number, h is experimental convective heat transfer co-efficient in W/m² K, Dh is Hydraulic Diameter, and knf is the thermal conductivity of nanofluid. The hydraulic diameter of the tubes can be calculated using Eq

$$D_h = (4A_{RC}) / P \quad (5.9)$$

where, Dh stands for hydraulic diameter of the radiator, A_{RC} is radiator tube cross-sectional area, and P is the perimeter of the tube.

NUMERICAL AND EXPERIMENTAL DATA

% CONCEN-TRATION	Flow rate(LPH)	Inlet temp (T _{in})	EXP outlet temp (T _{out})	CFD outlet temperature (T _{COU} T)	EXP ΔT	CFD ΔT	EXP Q(W)	CFD Q(W)
	150	45.1	39.9	40.6	5.2	4.5	678.7872	587.412
1% CuO	200	44.2	39.5	39.896	4.7	4.304	818.0256	750.1025
	250	43.4	39.1	39.782	4.3	3.618	935.508	785.267
	150	46	39.9	40.7	6.1	5.3	755.79	656.67
2% CuO	200	45.3	39.6	40.486	5.7	4.814	958.16	795.2728
	250	44.5	39.2	39.71	5.3	4.79	1177.05	988.722
	150	48.3	40.8	42	7.5	6.3	840.672	735.588
3% CuO	200	47.4	40.5	41.42	6.9	5.98	1074.192	930.9664
	250	47.2	40.4	41.769	6.8	5.431	1323.28	1056.8726



% CONC.	EXP Tb (Bulk temp)	CFD Tb (Bulk temp)	Tw (wall temp)	h(W/m ² K) EXP	h(w/m ² k) CFD	Nusselt number(Nu)EXP	Nusselt number(Nu)CFD
	42.5	42.85	36.1	2651.5125	2175.6	45.31675909	42.951
1% CuO	41.85	41.755	35.5	3220.573228	2998.011	55.04252427	51.23874355
	41.35	40.75	35.3	3865.735537	3602.142	66.06893464	61.5638849
	42.95	42.837	37.2	3286.043478	2912.320	53.25656672	47.19967518
2% CuO	42.45	41.661	36.5	4025.882353	3852.319	65.24705882	62.43414067
	41.85	41.285	35.6	4708.2	4347.941	76.30531034	70.46664544
	44.55	44.12	38.5	3473.85124	3272.188	55.3461045	52.1331745
3% CuO	43.95	44.7	37.9	4438.809917	3422.670	72.1378	54.53068395
	43.8	44.29	37.5	5251.111111	3891.283	83.66177024	61.99672025

WATER	Flow rate(LPH)	Cp (J/Kg K)	T _{in}	EXP T _{out}	CFD T _{out}	EXP ΔT	CFD ΔT	EXP Q(W)	CFD Q(W)
	150	4180	46.1	42.7	43.017	3.4	3.083	596.904	541.25148
	200	4180	45.5	42.4	42.719	3.1	2.781	725.648	650.97648
	250	4180	44.7	41.9	42.539	2.8	2.31	819.28	675.906

W A T E R	EXP T _b (Bulk temp)	CFD T _b (Bulk temp)	T _w (wall temp)	h(W/m ² K) EXP	H(w/m ² k)CFD	Nusselt number(Nu) EXP	Nusselt number(Nu) CFD
	44.9	44.5585	35.5	1587.510638	1493.766849	24.871	21.93970059
	43.98	44.1095	35.9	2245.19802	1982.387722	35.17476898	31.05740764
	43.3	42.87	35.4	2592.658228	2262.068273	40.61831224	35.43906961

Sample Calculation:

For 1% CuO –
For Heat transfer,

$$Q = \dot{m} * C_p * (T_{in} - T_{out})$$

$$Q = 150 * 0.00028 * 3108 * (45.1 - 39.9)$$

$$Q = 678.7872 \text{ W}$$

For convective heat transfer rate coefficient,

$$n * h * A_s * (T_b - T_w) = Q$$

$$n * h * A_s * (T_b - T_w) = \dot{m} * C_p * (T_{in} - T_{out})$$

$$h = \dot{m} * C_p * (T_{in} - T_{out}) / n * A_s * (T_b - T_w)$$

No. of tubes, n = 90

$$T_b = T_{in} + T_{out} / 2$$



$$T_b = 45.1 + 39.9/2$$

$$T_b = 42.5 \text{ }^\circ\text{C}$$

$$h = (150 * 0.00028 * 3108 * (45.1 - 39.9)) / (90 * 0.00441146 * 10^{-3} * (42.5 - 36.1))$$

$$h = 2651.5125 \text{ W/m}^2\text{k}$$

$$Nu = h * Dh / k$$

$$Nu = 2651.5125 * 0.0047 / 0.275$$

$$Nu = 45.3176$$

For 1% CuO –

For Heat transfer,

$$Q = \dot{m} * Cp * (T_{in} - T_{out})$$

$$Q = 150 * 0.00028 * 3108 * (45.1 - 39.9)$$

$$Q = 678.7872 \text{ W}$$

For convective heat transfer rate coefficient,

$$n * h * As * (T_b - T_w) = Q$$

$$n * h * As * (T_b - T_w) = \dot{m} * Cp * (T_{in} - T_{out})$$

$$h = \dot{m} * Cp * (T_{in} - T_{out}) / n * As * (T_b - T_w)$$

No. of tubes, $n = 90$

$$T_b = T_{in} + T_{out} / 2$$

$$T_b = 45.1 + 39.9/2$$

$$T_b = 42.5 \text{ }^\circ\text{C}$$

$$h = (150 * 0.00028 * 3108 * (45.1 - 39.9)) / (90 * 0.00441146 * 10^{-3} * (42.5 - 36.1))$$

$$h = 2651.5125 \text{ W/m}^2\text{k}$$

$$Nu = h * Dh / k$$

$$Nu = 2651.5125 * 0.0047 / 0.275$$

$$Nu = 45.3176$$



VALIDATION OF CFD WITH EXPERIMENTAL RESULTS:

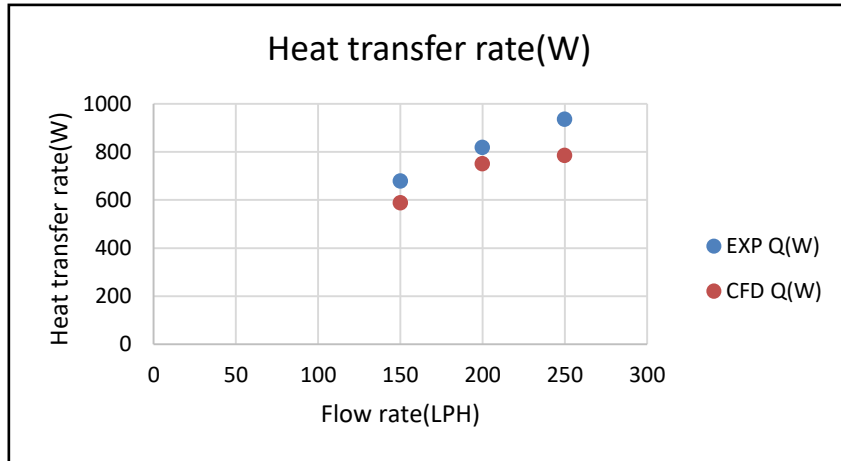


Chart 1: Heat Transfer vs. Flow Rate for 1% concentration

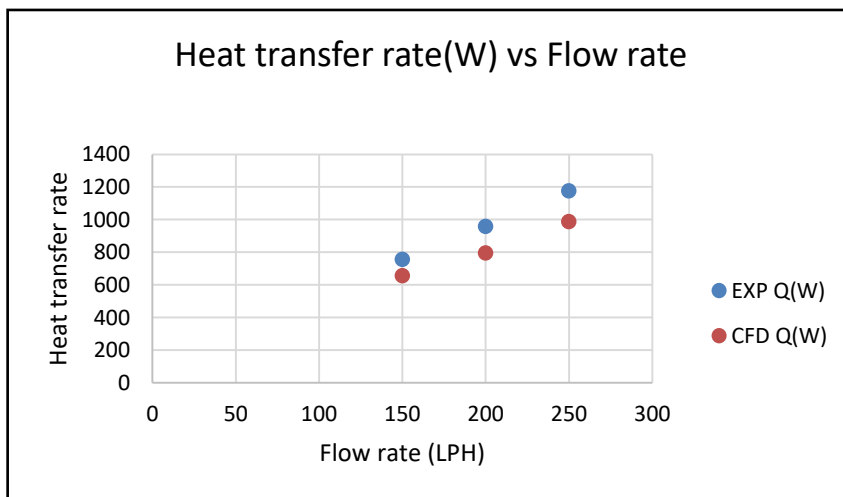


Chart 2: Heat Transfer vs. Flow Rate for 2% concentration

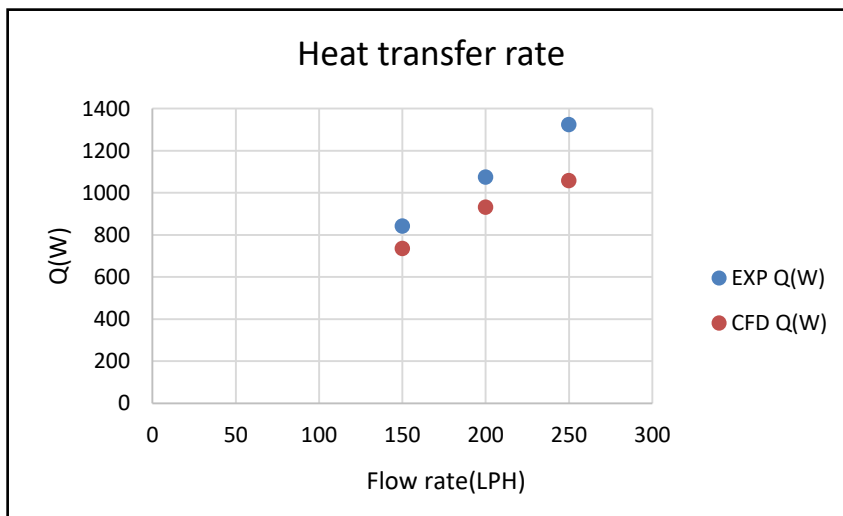


Chart 3: Heat Transfer vs. Flow Rate for 3% concentration



V. CONCLUSION

Ethylene-based Copper Oxide (CuO) nanofluids with particle concentrations of 1%, 2%, and 3% are utilised as nano-coolants in this work. These nanofluids are used at coolant inlet temperatures ranging from 40 to 50 degrees Celsius. The nanofluid flow rate is changed from 150 to 250 LPH. Extensive experimental study is performed to assess the performance of an automotive vehicle radiator employing nanofluids in terms of convective heat transfer coefficient, heat transfer rate, and Nusselt number, and the following results are reached:

- With increased nanoparticle concentration in the coolant the temperature difference between the inlet and outlet of radiator increases.
- With the increase of flow rate the temperature difference between inlet and outlet of radiator decreases.
- For the same mass flow rate, the heat transfer rate is higher for the nanofluid with higher nanoparticle concentrations.
- For the same mass flow rate, h is higher for the nanofluids with higher concentrations.
- For experimental analysis, a significant rise in the heat transfer rate of 57.407% at 250 LPH and Nusselt number 83 were noticed for the Ethylene based 3% concentration of Copper oxide (CuO) nanofluid. As for Ethylene based 2% concentration of Copper oxide (CuO) nanofluid it was 55.6% at 250 LPH and 37.82% at 250 LPH for 1% concentration of Copper oxide (CuO) nanofluid respectively.
- For experimental analysis, a significant rise in the convective coefficient of heat transfer, h of 51.11% at 250 LPH and Nusselt number 83 were noticed for the Ethylene based 3% concentration of Copper oxide (CuO) nanofluid. As for Ethylene based 2% concentration of Copper oxide (CuO) nanofluid it was 45.7% at 250 LPH and 45.1% at 250 LPH for 1% concentration of Copper oxide (CuO) nanofluid respectively.
- The Nusselt number of the nanofluids increases with increasing flow rates which implies enhanced heat transfer by convection in the radiator.
- The Nusselt number of the nanofluids increases with the increase in their nanoparticle concentration.
- For all three nanofluids at different mass flow rates, the experimental results are validated with CFD results in the radiator. The heat transfer rate is more in experimental results than the CFD results.
- Convection heat transfer coefficient, h is less in CFD results. Numerical and experimental results are in good agreement with each other.

REFERENCES

- [1] R. Prasanna Shankara, N.R. Banapurmath, Abhinandan D'Souza "An insight into the performance of radiator system using ethylene glycol-water based graphene oxide nanofluids.", Alexandria University Journal (2022)61,5155-5167.
- [2] K.Y. Leong, R. Saidur "Performance investigation of an automotive car radiator operated with nanofluid-based coolants (nanofluid as a coolant in a radiator)", Applied Thermal Engineering 30 (2010) 2685-2692.
- [3] Mohd Muzammil Zubair, Md. Seraj, Mohd. Faizan, Mohd Anas, Syed Mohd. Yahya "Experimental study on heat transfer of an engine radiator with TiO₂/ EG water nano coolant", SN Applied Sciences (2021) 3:434 | <https://doi.org/10.1007/s42452-021-04441-7>.
- [4] Rohit S. Khedkar, Shriram S. Sonawane, Kailas L. Wasewar "Influence of CuO nanoparticles in enhancing the thermal conductivity of water and monoethylene glycol based nanofluids", International Communications in Heat and Mass Transfer 39 (2012) 655-669.
- [5] C. Selvam, R. Solaimalai Raja, D. Mohan Lal, Sivasankaran Harish "Overall heat transfer coefficient improvement of an automobile radiator with graphene based." International Journal of Heat And Mass Transfer 115 (2017) 580-588.
- [6] M. Naraki, S.M. Peyghambarzadeh, S.H. Hashemabadi, Y. Vermahmoudi "Parametric study of overall heat transfer coefficient of CuO/water nanofluids in a car radiator" International Journal of Thermal Sciences 66 (2013) 82-90.
- [7] M. Allen Zennifer, S. Manikandan, K.S. Suganthi, V. Leela Vinodhan, K.S. Rajan "Development of CuO-ethylene glycol nanofluids for efficient energy management: Assessment of potential for energy recovery" Energy Conservation and Management 105 (2015) 685-696.
- [8] Raju Jadar, K.S. Shashishekar, S. R. Manohara "Nanotechnology Integrated Automobile Radiator" Materials Today: Proceedings 4 (2017) 12080-12084.



SJIF Scientific Journal Impact Factor

Impact Factor: 8.423



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details