Performance Assessment of Radiator Using Various Combinations of Nanofluids as Coolant

Zainaba Rauf[1], Siddhesh Gaikar[2], Umesh Rasal[3], Harsh Mahale[4] Prof.Pankaj Rathod[5], Prof. Trupti[6], Prof. Bhavna Ingole[7], Dr. Usha Pawar[8]

[1234] *Students of Department of Mechanical Engineering, Datta Meghe College of Engineering, Airoli*
[56789] *Assistant Professor of Department of Mechanical Engineering, Datta Meghe College of Engineering, Airoli.*

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1.Abstract - Radiator cooling efficiency is essential for maintaining engine performance and preventing overheating, yet conventional coolants like water and ethylene glycol (EG) have low thermal conductivity, limiting heat dissipation. This study explores the use of ethylene glycol-based Copper Oxide (CuO) nanofluids at concentrations of 1%, 2%, and 3% to enhance radiator performance by leveraging the superior thermal properties of nanoparticles. An experimental setup was designed to evaluate heat transfer efficiency at varying flow rates, analyzing key parameters such as heat transfer coefficient, thermal conductivity, and overall cooling effectiveness. The results indicate that increasing CuO nanoparticle concentration improves heat transfer, with the 3% CuO nanofluid demonstrating the highest cooling efficiency; however, higher concentrations may lead to stability concerns over time. These findings suggest that nanofluids significantly enhance radiator performance, offering a viable alternative to conventional coolants while contributing to improved engine efficiency and longevity. Optimizing nanoparticle concentration and coolant flow rate can further improve heat dissipation, reducing engine wear and overheating risks. Future research should focus on enhancing nanofluid stability and investigating long-term effects on radiator materials to ensure their practical applicability in automotive cooling systems.

***Key Words*:** Nanofluids, radiator performance, heat transfer, Copper Oxide, automotive cooling, thermal conductivity.

2.INTRODUCTION

This study investigates the enhancement of radiator cooling efficiency using Copper Oxide (CuO) nanofluids in ethylene glycol at varying concentrations (1%, 2%, and 3%), analyzing their thermal performance through an experimental setup that evaluates heat transfer efficiency, coolant flow rates, and overall radiator effectiveness compared to conventional coolants. Nanofluids, due to their superior thermal conductivity and enhanced convective heat transfer properties, offer a promising alternative to traditional coolants like water and ethylene glycol, which have limited heat dissipation capabilities. The experimental setup includes a controlled radiator test system equipped with thermocouples, flow meters, and a heat exchanger to accurately measure temperature variations and cooling performance. The results demonstrate that increasing CuO nanoparticle concentration improves heat transfer, with the 3% CuO nanofluid exhibiting the highest efficiency; however, stability concerns arise at higher concentrations due to potential nanoparticle agglomeration. These findings suggest that nanofluids can significantly optimize engine cooling, reduce overheating risks, and enhance automotive thermal management. Future research should focus on improving nanofluid stability, optimizing flow dynamics, and assessing the long-term effects of nanoparticles on radiator components for practical applications in vehicle cooling systems.

1. LITERATURE SURVEY

- **Shankara et al. (2022)** found that graphene oxide nanofluids increased radiator heat dissipation by 42.76%.
- **Bozorgan et al. (2012)** demonstrated that CuO-water nanofluids improved the heat transfer coefficient by 10%.
- **Azman et al. (2023)** reported that hybrid nanofluids, such as Al_2O_3-CuO mixtures, provided better cooling efficiency than conventional fluids.

2. PROBLEM DEFINITION

Traditional radiator coolants have limited heat transfer capabilities, reducing engine efficiency and increasing overheating risks. This study aims to:

- Evaluate the impact of CuO nanofluids on radiator cooling performance.
- Compare the thermal efficiency of nanofluids with conventional coolants.
- Assess the effect of nanoparticle concentration and coolant flow rate on heat dissipation.

3. RESEARCH METHODOLOGY

6.1 Nanofluid Preparation

To enhance the thermal conductivity of the coolant, Copper Oxide (CuO) nanoparticles were dispersed in an ethylene glycol (EG) base fluid at concentrations of 1%, 2%, and 3%. The nanofluids were prepared using **ultrasonication**, a process that applies high-frequency sound waves to break apart nanoparticle agglomerations and ensure uniform distribution within the base fluid. This step is critical in preventing sedimentation and maintaining the stability of the nanofluid. Additionally, a surfactant may be used to improve nanoparticle dispersion and minimize clustering, thereby enhancing the overall effectiveness of the coolant.

6.2 Experimental Setup

The experimental system was designed to evaluate the cooling efficiency of CuO nanofluids in an automotive radiator under controlled conditions. The setup consisted of the following components:

- **Radiator:** A standard automotive radiator was used as the heat exchanger.
- **Circulation Pump:** Ensured continuous coolant flow at varying rates to simulate real-world operating conditions.
- **Thermocouples:** Precisely measured inlet and outlet temperatures at different test points to determine the heat dissipation capability.
- **Flow Control Valves:** Allowed adjustment of coolant flow rates to assess the impact of varying flow conditions on heat transfer efficiency.
- **Data Acquisition System:** Collected temperature and flow rate data for analysis.

The nanofluid was circulated through the radiator while maintaining controlled input conditions. The temperature differences between the inlet and outlet were recorded to assess the cooling performance.

6.3 Performance Evaluation

The effectiveness of the nanofluids was determined by analyzing key thermal performance parameters, which included:

- **Heat Transfer Coefficient (HTC):** Measures the efficiency of heat dissipation from the radiator to the surrounding environment. A higher HTC indicates improved cooling performance.
- **Thermal Conductivity:** Evaluates the ability of the nanofluid to conduct heat. The addition of CuO nanoparticles enhances the thermal conductivity, leading to better heat transfer rates.
- **Cooling Effectiveness:** Compares the temperature reduction achieved using CuO nanofluids against conventional ethylene glycol-based coolants. Improved cooling effectiveness suggests better engine performance and lower overheating risks.
- **Pressure Drop:** Assesses any additional resistance to flow caused by the presence of nanoparticles. A significant increase in pressure drop could indicate potential clogging or flow resistance issues.
- **Nanoparticle Stability:** Observes the long-term dispersion of CuO nanoparticles in the coolant to ensure effective performance without sedimentation.

By systematically analyzing these parameters, the study aims to determine the optimal CuO concentration and flow conditions that maximize radiator efficiency while maintaining nanofluid stability and minimizing potential drawbacks such as increased viscosity or pressure drop.

4. RESULTS

- **Effect of Nanoparticle Concentration:** Higher CuO concentrations improved heat transfer, with 3% CuO nanofluid showing the best performance.
- **Influence of Flow Rate:** Optimal flow rates enhanced cooling efficiency, but excessive flow led to pressure drops.
- **Comparison with Conventional Coolants:** CuO nanofluids reduced radiator temperature by 4–6°C more than traditional coolants, confirming their effectiveness.

Type of Coolant	Flow Rate (LPH)	Inlet Temp. (T_{in})	Outlet Temp. (T_{out})	Exp. ΔT ($T_{in} - T_{out}$)
Water	150	45.1	42.2	2.9
	200	44	41.6	2.7
	250	43.6	40.2	3.4

Table -1: Reading of water

Type of Coolant	Flow Rate (LPH)	Inlet Temp. (T_{in})	Inlet Temp. (T_{in})	Inlet Temp. (T_{in})
Antifreeze	150	45	41.4	3.6
	200	44.4	41.2	3.2
	250	43	39.2	3.8

Table -2: Reading of antifreeze

Type of Coolant	Flow Rate (LPH)	Inlet Temp. (T_{in})	Inlet Temp. (T_{in})	Inlet Temp. (T_{in})
1% CuO	150	45.1	39.9	5.2
	200	44.2	39.5	4.7
	250	43.4	39.1	4.3
2% CuO	150	46	39.9	6.1
	200	45.3	39.6	5.7
	250	44.5	39.2	5.3

Table -3: Reading of concentration of nanofluids

5. FUTURE SCOPE

Future research should focus on:

- Enhancing nanofluid stability for long-term use.
- Investigating the effects of nanofluids on radiator materials.
- Conducting computational fluid dynamics (CFD) simulations for further performance optimization.

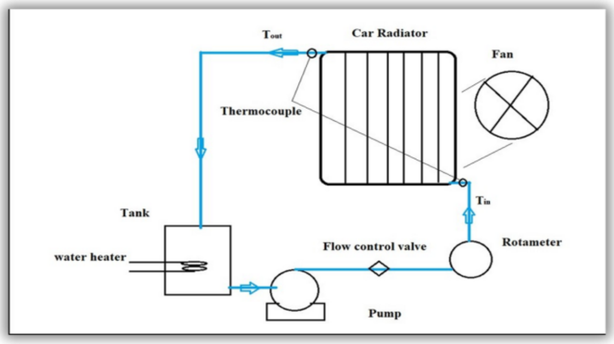

Fig -1: **Schematic Diagram**

6. CONCLUSIONS

- **Enhanced Heat Transfer Efficiency:** Ethylene glycol-based Copper Oxide (CuO) nanofluids significantly improve radiator cooling, reducing temperatures by **4–6°C** compared to conventional coolants.
- **Optimal Nanoparticle Concentration:** Increasing CuO concentration enhances thermal conductivity and heat dissipation, with **3% CuO nanofluid** showing the highest efficiency.
- **Stability Concerns:** Excessive nanoparticle concentrations may lead to **agglomeration and sedimentation**, affecting long-term performance.
- **Flow Rate Optimization:** Proper control of flow rates ensures **efficient heat exchange**, minimizing pressure drops and preventing flow resistance issues.

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