Enhancement of Radiator Efficiency by Using Magnesium Oxide (MgO) Nanoparticles

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Abstract: *In modern automotive and industrial systems, efficient thermal management is critical for ensuring performance, reliability, and longevity. Traditional coolants like water or ethylene glycol have limited thermal conductivity, leading to inefficient heat dissipation under high-performance conditions. To address this challenge, the use of nanofluids—fluids enhanced with nanoparticles—has emerged as a promising solution. This article explores the application of Magnesium Oxide (MgO) nanoparticles in radiator systems, focusing on how they enhance heat transfer, improve cooling efficiency, and reduce the risk of overheating.*

Keywords*:* Radiator, Nanofluid, Magnesium Oxide

I. INTRODUCTION

A radiator is an essential component in internal combustion engines and industrial machinery, responsible for dissipating the excess heat generated during operation. Conventional coolants have low thermal conductivity, which limits their heat transfer capability. Nanofluids, which are base fluids infused with nanoparticles, offer a significant improvement in thermal performance. Among various nanoparticle options, **Magnesium Oxide (MgO)** stands out due to its high thermal conductivity, stability, and resistance to corrosion.

Why Choose Magnesium Oxide (MgO) Nanoparticles?

Magnesium Oxide (MgO) nanoparticles offer a range of desirable properties that make them highly suitable for thermal management applications, particularly in automotive radiator systems. Key advantages include:

- **High Thermal Conductivity**: MgO enhances the heat absorption and dissipation capacity of the base fluid, significantly improving the radiator's cooling efficiency.
- **Excellent Chemical Stability**: These nanoparticles remain stable over time without reacting with the base fluid, ensuring long-term performance.
- **Corrosion Resistance**: MgO is non-corrosive and compatible with radiator components, reducing the risk of system degradation.
- **Enhanced Convective Heat Transfer**: The addition of MgO improves the fluid's flow and heat exchange characteristics, contributing to superior thermal performance.

These attributes collectively make MgO an ideal additive for enhancing the efficiency and reliability of conventional coolants.

II. EXPERIMENTAL SETUP

Preparation of MgO-Based Nanofluid

The MgO nanofluid was prepared using a controlled **ultrasonic-assisted chemical precipitation** technique, ensuring fine particle size and uniform dispersion. The preparation steps were as follows:

- **Solution Preparation**: Separate 1N solutions of magnesium sulfate heptahydrate ($MgSO_4 \cdot 7H_2O$) and sodium hydroxide (NaOH) were prepared in distilled water.
- **Chemical Precipitation**: The NaOH solution was gradually added dropwise to the $MgSO_4$ solution under vigorous stirring, resulting in the formation of magnesium hydroxide [$Mg(OH)_2$] as a white precipitate.

- **Ultrasonic Processing**: The resulting mixture was subjected to ultrasonic agitation. This step reduced the particle size to the nanoscale and ensured uniform dispersion of particles within the solution.
- **Drying and Conversion**: The precipitate was separated using filter paper and dried in an oven at 120–150°C to obtain pure MgO Nano powder.

The dried MgO nanoparticles were then uniformly dispersed in distilled water to create a stable nanofluid used for performance testing in the radiator setup.

A customized test rig was fabricated using a Duke 390 radiator, a submersible water pump, digital thermometer sensors, and flow measurement tools. The system was tested using:

- **Water as the base fluid** (control)
- **MgO nanofluid** with varying concentrations

Fig. 1 Experimental Setup

Temperatures at the radiator inlet and outlet were recorded, and the heat transfer rates were calculated.

III. RESULTS AND DISCUSSION

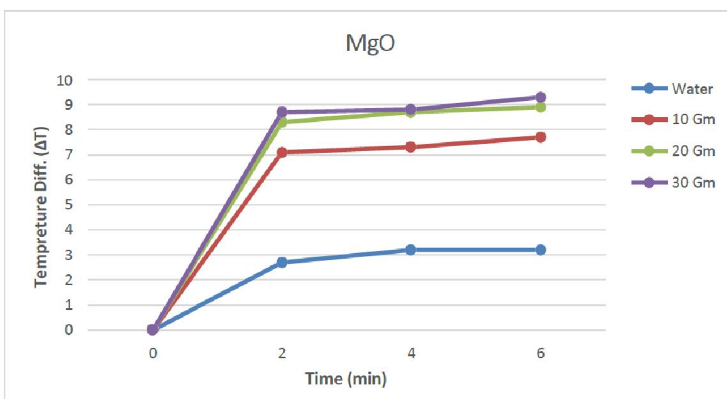

Figure – 2 : the temperature difference (ΔT) over time using MgO nanofluids at different concentrations (10 g, 20 g, 30 g) compared to water

The MgO nanofluid **increased the overall heat transfer rate** compared to pure water.

With increasing nanoparticle concentration, there was a notable **reduction in outlet temperature**, indicating better cooling efficiency.

The calculated **effectiveness and NTU** (Number of Transfer Units) confirmed improved thermal performance.

The use of MgO nanofluid allowed for better energy balance and faster heat dissipation.

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Advantages of Using MgO Nanoparticles

- **Enhanced radiator efficiency** without changing existing hardware.
- **Lower risk of engine overheating**, especially under high load.
- **Potential for smaller and lighter cooling systems**, reducing vehicle weight.
- **Eco-friendly option** due to reduced fuel consumption and emissions from better thermal management.

Limitations and Future Scope

While lab results are promising, the study did not account for long-term stability or corrosion effects in real-world environments. Future research should explore:

- Long-term behavior of MgO nanofluids in operational engines
- Hybrid nanofluid combinations (e.g., MgO-ZnO)
- Scale-up for commercial automotive applications

IV. CONCLUSION

The integration of Magnesium Oxide nanoparticles into conventional coolant fluids presents a significant opportunity for improving the thermal efficiency of radiator systems. The experimental evidence confirms that MgO nanofluids can enhance heat transfer, reduce engine temperature, and improve overall system performance without requiring major modifications. This innovative approach offers a cost-effective, scalable solution for advancing cooling technology in automotive and industrial sectors.

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