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EXPERIMENTAL INVESTIGATION ON THE PERFORMANCE OF A VAPOUR COMPRESSION REFRIGERATION SYSTEM USING HYDROCARBON REFRIGERANTS AND NANO LUBRICANTS

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Abstract

The growing demand for energy-efficient and environmentally sustainable refrigeration systems has driven significant research toward alternative refrigerants and advanced heat transfer enhancement techniques. Conventional refrigerants, particularly hydrofluorocarbons (HFCs), are being phased down due to their high Global Warming Potential (GWP) and environmental impact. In this context, hydrocarbon refrigerants have emerged as promising substitutes due to their low GWP, favorable thermodynamic properties, and superior heat transfer characteristics. Simultaneously, recent advancements in nanotechnology have introduced nanofluids and nano lubricants as potential enhancers of thermal performance in refrigeration systems.

The present study investigates the experimental performance of a Vapour Compression Refrigeration (VCR) system operating with hydrocarbon refrigerant blends integrated with nano lubricant additives. The primary objective is to evaluate the influence of nanoparticles on system performance parameters such as compressor work, coefficient of performance (COP), heat transfer characteristics, and lubrication behavior. Nanoparticles such as Cerium Oxide (CeO_2) and Titanium Dioxide (TiO_2) are selected for this study due to their high thermal conductivity, chemical stability, and compatibility with refrigeration systems. These nanoparticles are dispersed in compressor lubricating oil to form nano lubricants, which are then introduced into the refrigeration cycle. The dispersion stability and concentration of nanoparticles play a crucial role in determining the overall system performance.

The experimental setup consists of a standard vapour compression refrigeration system equipped with essential components including compressor, condenser, expansion device, and

evaporator. The system is instrumented with temperature and pressure sensors at key locations to monitor thermodynamic states. Tests are conducted under controlled operating conditions for both baseline (without nanoparticles) and modified systems (with nano lubricants). The inclusion of nanoparticles in the lubricant is expected to enhance heat transfer and reduce friction losses within the compressor. Nanoparticles improve thermal conductivity, leading to better heat dissipation in the compressor and enhanced evaporator performance. Additionally, their presence influences the rheological properties of the lubricant, particularly viscosity. While some studies report an increase in viscosity with nanoparticle addition, this can improve lubrication quality and reduce mechanical wear, provided the concentration remains within optimal limits. Experimental results indicate a noticeable improvement in system performance with the addition of nano lubricants. The coefficient of performance (COP) is observed to increase due to reduced compressor work and improved heat transfer efficiency. The enhanced lubrication properties contribute to smoother compressor operation, thereby lowering energy consumption. Furthermore, the hydrocarbon refrigerant blend, combined with nano additives, demonstrates superior thermodynamic performance compared to conventional refrigerants.

However, the study also highlights certain challenges associated with nano refrigerants, including stability of nanoparticle dispersion, potential agglomeration, and changes in viscosity that may affect flow characteristics. Therefore, careful optimization of nanoparticle concentration is essential to achieve maximum performance benefits without compromising system reliability. The findings of this investigation confirm that the integration of hydrocarbon refrigerants with nano lubricants offers a viable pathway toward improving the efficiency and sustainability of refrigeration systems. The synergistic effect of enhanced thermal conductivity and improved lubrication leads to better overall system performance. Future work may focus on long-term stability analysis, optimization of nanoparticle size and concentration, and exploration of other nanoparticle materials. Additionally, studies on environmental impact, safety considerations (especially flammability of hydrocarbons), and scalability for industrial applications are recommended.

In conclusion, this study demonstrates that nano-enhanced refrigeration systems have significant potential in advancing next-generation cooling technologies, aligning with global efforts toward energy efficiency and environmental sustainability.

Keywords

Nano refrigerants, Nano lubricants, Vapour Compression Refrigeration, Hydrocarbon refrigerants, Coefficient of Performance, Compressor work, CeO_2, TiO_2