Heat Transfer Characteristics of Al2O3 Based Nano refrigerants in The Evaporator and Condenser of Vapor Compression Refrigeration Systems

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Abstract
Document Sections

Abstract:
The performance and energy consumption of the vapor compression refrigeration system (VCRS) is influenced by the rate of heat transfer between the system and its environment. Two-phase flow, boiling with heat transfer occur within the evaporator and the condenser of the VCRS. The improvement in two-phase flow, boiling and heat transfer coefficient in these components using nano refrigerants possess the propensity to increase the system's performance and energy efficiency and reduces the energy carbon footprint of the system. The influence of nanoparticle concentration of aluminum oxide (Al 2 O 3) on the two-phase flow heat transfer in the condenser and the evaporator using R134a and R600a refrigerants in the VCRS was analyzed in this study. The ANSYS fluent software was employed to model and analyze the process in the condenser and evaporator. The result obtained showed that convective heat transfer of pure R600a and Al 2 O 3 /R600a nano refrigerants was higher than that of pure R134a and Al 2 O 3 /R134a nano refrigerants. The Prandtl and Nusselt numbers decreased as the nanoparticle concentration increased. Thermal diffusion was more prominent than the momentum diffusion as the temperature increased, despite the increase in the nanoparticle concentration. The numerical simulation results established that the convective heat transfer coefficient, Nusselt number and Prandtl number of the nano refrigerant depends on the mass concentration of nanoparticles.

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I. Introduction

The global world is currently experiencing energy crises and climatic changes. These challenges have motivated researchers and innovators to create innovative solutions that will reduce the energy consumed by energy system thereby reducing the carbon footprint of the system. The vapor compression refrigeration system (VCRS) is commonly utilized in houses and industries for the purpose of preservation and cooling but according to U.S Energy Information Administration, refrigeration and air conditioning consumes about 25% percent of the residential electricity energy [1]. The thermophysical properties of refrigerant used in VCRS as heat transfer fluid largely determine the performance of the system and the rate of heat transfer [2]. Effective heat transfer within the condenser and evaporator of the VCRS is essential in the performance and energy consumption of the system. Within the evaporator and the condenser of the VCRS, boiling and two-phase flow with heat transfer occur in each component. The improvement in heat transfer coefficient (HTC), boiling and two-phase flow in these components possess the propensity to increase the system's energy efficiency and performance, reduce the energy carbon footprint of the system, thereby reducing the emission of greenhouse gases into the environment and the ozone layer depletion [3]-[6]. Enhancement of the HTC in flow boiling and two-phase flow can be achieved by dispersing nanoparticles into the refrigerant or lubricant used in the VCRS and this enhancement correlates to high energy efficiency of the system [7],[8]. Metallic and metallic oxide nanoparticles possess high thermal conductivity, and they are mostly used in enhancing the thermophysical properties of the refrigerants [2],[3].

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