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Performance improvement strategies of R1234yf in vapor compression refrigeration system as a R134a replacement: A review

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ABSTRACT

R1234yf, a substitute for R134a, shares similar thermodynamic behavior and eco-friendly properties with low global warming potential. However, performance and flammability issues hampered its adoption in vapor compression refrigeration systems (VCRS). This review examines diverse strategies implemented in R1234yf-based VCRS, including internal heat exchanger (IHX) utilization, ejector implementation, refrigerant charge optimization, HVAC component optimization, nanolubricant application, and R1234yf azeotropic mixture usage. Findings indicate significant enhancements in VCRS performance using R1234yf. IHX and precise condenser subcooling improve the coefficient of performance (COP). The ejector yields substantial performance gains of 4% to 23.29%. Increased refrigerant charge levels beyond the optimum enhance cooling capacity. Optimizing the compressor, expansion valve, and system parameters leads to notable improvements of 11.3% and 8% in cooling capacity and COP, respectively, for R1234yf-based systems. Nanolubricants yield noteworthy enhancements of up to 15.7% in cooling capacity and 9.8% in COP. Employing R1234yf azeotropic mixture effectively addresses flammability and performance concerns, albeit with a higher global warming potential (GWP). Further research is necessary to utilize lower GWP refrigerants in VCRS through various strategies efficiently.

1. Introduction

Environmental concerns, such as global warming and ozone depletion, have been recognized as a key issue that authorities must tackle effectively in many nations as the 21st century began. Numerous research studies have been conducted to develop more effective refrigerants for refrigeration systems [1,2]. The Montreal Protocol restricted the use of refrigerants owing to the detrimental impact of chlorofluorocarbon (CFC) refrigerants on climate change. Today, CFC refrigerants cannot be used in these applications. As a working medium in a refrigeration system, the use of a refrigerant with a high ozone depletion potential (ODP) and global warming potential (GWP) has been recognized as a contributor to global warming and ozone depletion. Incorrect handling, faulty charging procedures, and refrigeration system leaks are responsible for releasing this dangerous refrigerant into the environment. In addition, indirect emissions resulting from the energy consumption of the refrigeration cycle have been observed to have a considerable impact on the environment [3]. Fluorochemicals and Hydrochlorofluorocarbons (HCFCs) have been recognized as harmful refrigerant components that impact the environment and ozone [4]. Therefore, the Vienna Convention and the Montreal Protocol were enacted to control the use of these and other potentially destructive compounds [5,6]. Various types of refrigerants are currently available

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